S. HRG. 100-471

NEW USES FOR FARM AND FOREST PRODUCTS

HEARING

BEFORE THE

SUBCOMMITTEE ON AGRICULTURAL RESEARCH AND GENERAL LEGISLATION

OF THE

COMMITTEE ON AGRICULTURE, NUTRITION, AND FORESTRY
UNITED STATES SENATE

ONE HUNDREDTH CONGRESS

FIRST SESSION

ON

THE REPORT OF THE NEW FARM AND FOREST PRODUCTS TASK FORCE AND TO INVESTIGATE HOW TO RAISE FARM INCOME BY COMMERCIALIZING NEW FARM AND FORESTRY PRODUCTS

JUNE 26, 1987

Printed for the use of the
Committee on Agriculture, Nutrition, and Forestry

U.S. GOVERNMENT PRINTING OFFICE
81-459 WASHINGTON : 1988

For sale by the Superintendent of Documents, Congressional Sales Office
U.S. Government Printing Office, Washington, DC 20402

S161-16

81-459 O - 88 - 1

COMMITTEE ON AGRICULTURE, NUTRITION, AND FORESTRY

PATRICK J. LEAHY, Vermont, *Chairman*

JOHN MELCHER, Montana
DAVID H. PRYOR, Arkansas
DAVID L. BOREN, Oklahoma
HOWELL HEFLIN, Alabama
TOM HARKIN, Iowa
KENT CONRAD, North Dakota
WYCHE FOWLER, Jr., Georgia
THOMAS A. DASCHLE, South Dakota
JOHN B. BREAUX, Louisiana

RICHARD G. LUGAR, Indiana
ROBERT DOLE, Kansas
JESSE HELMS, North Carolina
THAD COCHRAN, Mississippi
RUDY BOSCHWITZ, Minnesota
MITCH McCONNELL, Kentucky
CHRISTOPHER S. "KIT" BOND, Missouri
PETE WILSON, California
DAVID K. KARNES, Nebraska

Charles Riemenschneider, *Staff Director*
John Podesta, *Chief Counsel*
Christine Sarcone, *Chief Clerk*
Charles Conner, *Staff Director for the Minority*

Subcommittee on Agricultural Research and General Legislation

KENT CONRAD, North Dakota, *Chairman*

DAVID L. BOREN, Oklahoma

PETE WILSON, California
DAVID K. KARNES, Nebraska

CONTENTS

FRIDAY, JUNE 26, 1987

Page
Conrad, Hon. Kent, a U.S. Senator from North Dakota, opening statement 1

CHRONOLOGICAL LIST OF WITNESSES

- Bentley, Dr. Orville G., Office of the Secretary, Assistant Secretary for Science and Education, U.S. Department of Agriculture 2
  - Material subsequently supplied for the record pertaining to spending on research, Department of Agriculture funded 5
- O'Connell, Dr. Paul F., Deputy Administrator, Office of Grants and Programs Systems, Cooperative State Research Service, U.S. Department of Agriculture 10
- Sampson, Dr. Ronald L., Chairman, New Farm and Forest Products Task Force 17
  - Prepared statement 21
  - New Farm and Forest Products—Responses to the Challenges and Opportunities Facing American Agriculture, a report from the New Farm and Forest Products Task Force to the Secretary, U.S. Department of Agriculture, Washington, DC, June 25, 1987 28
- Gain, Jeffrey W., chief executive officer, National Corn Growers Association (NCGA) 90
  - Prepared statement 100
  - "Corn News," article, "Denver, Other Cities Consider Mandating Ethanol Fuels To Clean Air" 105
  - A Survey of Potential New Corn Uses, report by Kelly Harrison Associates, Inc., August 1986 110
- Jolliff, Dr. Gary D., professor of crop science, Oregon State University, and member, New Farm and Forest Products Task Force 94
  - Prepared statement 221
  - Statement before the New Farm and Forest Products Task Force, Washington, DC, June 25, 1987 230
  - New Corps and Products From American Agriculture: Rationale for Institutional Change and Strategic Planning 232
  - New Crop Development: Opportunity and Challenges 276
  - The Systematic Approach to Exploring Alternatives 307
  - Lebanon area, Chamber of Commerce, Lebanon, OR, meeting notice, dated December 19, 1986, with enclosures 312
  - 64th Oregon Legislative Assembly—1987 Regular Session, House Bill 2939 313
  - A proposal for Accelerated Commercial Development of Meadowfoam, prepared by the Meadowfoam Development Task Force, February 1987, submitted through Oregon Meadowfoam Growers Association, Salem, OR 314
  - Figure 1.—General structure of the fats and oils industry 323
  - Figure 2.—Cooperative Program to Accelerate Commercial Development of Meadowfoam 324
  - Proposal for a Regional Economic Development Strategy, Linn County, OR, February 1987 325
  - West, Charles P., Ph.D., president, Resin Research Laboratories, Inc., letter, dated March 3, 1987, to Mr. Charles D. Craig 326
  - New Crop, Farmers Weekly, September 13, 1985, Edward Long 328
  - "Europe Is Calling Out for More Meadowfoam," Farmers Weekly, March 28, 1986 329

ADDITIONAL MATERIAL SUPPLIED FOR THE RECORD

Page

Ladisch, Michael R., Laboratory of Renewable Resources Engineering, Purdue University, West Lafayette, IN 333

Center for Alternative Crops and Products, College of Agriculture, University of Minnesota 335

NEW USES FOR FARM AND FOREST PRODUCTS

FRIDAY, JUNE 26, 1987

U.S. Senate, Subcommittee on Agricultural Research and General Legislation of the Committee on Agriculture, Nutrition, and Forestry,

and Forestry,
Washington, DC.

The subcommittee met pursuant to notice, at 10 a.m., in room 332, Russell Senate Office Building, Hon. Kent Conrad (chairman of the subcommittee) presiding.

Present or submitting a statement: Senators Conrad and Karnes.

STATEMENT OF HON. KENT CONRAD, A U.S. SENATOR FROM NORTH DAKOTA

Senator Conrad. This hearing before the Subcommittee on Agricultural Research and General Legislation of the Senate Committee on Agriculture, Nutrition, and Forestry, will come to order.

Good morning and welcome to the first hearing of the Subcommittee on Agricultural Research and General Legislation.

The purpose of today's hearing is to receive the report of the New Farm and Forest Products Task Force. But, more important, it is to investigate how to raise farm income by commercializing—developing and marketing—new farm and forestry products.

The need is very clear:

The United States has vast agricultural resources idled due to low commodity prices arising from the glut in world grain markets.

Net farm income, adjusted for inflation, has fallen from an average of $40.4 billion per year in the 1970's to an average of about $24 billion in the 1980's—a drop of 40 percent.

In North Dakota, my home State, cash receipts from agricultural sales fell 22 percent between 1985 and 1986. Cash receipts from food and feed grains fell 36 percent.

Agricultural exports have fallen precipitously since 1980.

Natural instability in commodity markets has caused the deepest recession in American agriculture since the Great Depression. Developing new uses for farm and forestry products will reduce the instability by diversifying farm production and consumer demand.

In addition, agricultural and forestry products are more environmentally sound than many of the chemical products they can replace—we will hear more about this in the testimony. Farm and forestry products are renewable resources and are the basis of biodegradable products.

This country faces tremendous challenges in agriculture. But, we also have tremendous potential. We already have many innovative product ideas. In addition, Senator Harkin's bill, S. 970, the Alternative Agricultural Products Research Act of 1987, of which I am a cosponsor, promises to facilitate the development of more new products. S. 970 is a major legislative initiative for developing farm and forest products.

New product ideas are being developed at a rapid pace. We have heard about the rubber plant, guayule, for many years, but no commercial market for guayule rubber exists. Many other product ideas are also available, but undeveloped.

The key question is why more of these product ideas have not been commercial successes. What can the Department of Agriculture do that it is not doing now? What role can the private sector play? How can the commercialization of innovative product ideas be financed? How can we facilitate the development of commercially successful products? What are the leverage points where Federal action will reap large rewards in employment, higher farm income, and a more stable, diversified rural economy?

Today, we will probe for answers to these questions with the goal of determining what we can do to help revitalize the farm economy.

As our first witness, I want to call on Dr. Orville Bentley, the Assistant Secretary of Agriculture for Science and Education.

Dr. Bentley, we are pleased to have you here today and we will be happy to take your testimony.

STATEMENT OF DR. ORVILLE G. BENTLEY, OFFICE OF THE SECRETARY, ASSISTANT SECRETARY FOR SCIENCE AND EDUCATION, U.S. DEPARTMENT OF AGRICULTURE

Dr. **Bentley**. Mr. Chairman, and members of the subcommittee, I welcome the opportunity to appear before you today to discuss the report entitled, "Responses to the Challenges and Opportunities Facing American Agriculture," and to talk with you about some of the activities within the U.S. Department of Agriculture related to this subject.

Some of the remarks I will make address some of the questions you made during your opening statement, but I wanted to list some of the points that we think are relevant to the discussion of the report, so I would like to go to my prepared statement.

As background, this report was produced by a task force created by the Department following the October 1984 Secretary's Challenge Forum on New Uses for Farm and Forest Products. You will be hearing today from Dr. Ronald L. Sampson, chairman of the task force. Dr. Sampson and others from the private sector joined with representatives of USDA, other Federal agencies, and State members to focus on the need for developing new uses for the products of American agriculture and forestry. Let me stress that this is a report of the private-public task force, and does not necessarily reflect the official position of the Department. We have long recognized the need to expand the market base for agricultural products. The production of traditional crops and products continues to exceed domestic demand. Further, most foreign nations now have the increased capacity to feed and clothe themselves, thus impacting the markets for American farm products.

Our goal then must be to expand the size of the market for agricultural products, including nonfood uses. Many times products from American agriculture have simply displaced other products, leading to a change in market shares but little or no change in the size of the agricultural base.

To this end, I suggested in 1984 that the task force be given a specific assignment: To focus on the development of new farm and forest products which would not displace other agricultural products. Hence, the major thrust of the task force was to examine the development of industrial and nonfood uses of farm and forest products.

Mr. Chairman, I testified at the hearing before the Committee on Agriculture on May 15 related to the same topic. My remarks centered upon the fact that the Department has long been interested in the development of industrial products. I cited two specific examples of this longstanding interest. The 1940 Yearbook of Agriculture contained the following words: "One way to expand the farmer's market is to develop industrial uses for farm products."

Twenty-three years later, the 1963 Yearbook of Agriculture posed this question: "Why do we not grow a greater variety of crops, particularly to provide raw materials for industry?" The Agricultural Research Service is applying approximately $15.5 million to the industrial uses of agricultural commodities. In addition, there is research indirectly enhancing industrial uses amounting to $6.7 million and research on new crops funded at $2.7 million, bringing the total to $25.1 million. This important area of work is being expanded by a program to better utilize surplus crops. Toward this objective, Department scientists are performing research to expand markets for starch made from surplus corn and vegetable oil. This type of research comprises genetic engineering and novel chemical conversions. Scientists are also developing nonfood uses for starch made from grains, and oils from oilseed crops to reduce imports and promote exports. These include such items as human health care products, cosmetics, plastics, lubricants, and surface coatings. To better utilize surplus dairy products, scientists are using fermentation systems for converting lactose in whey to high value added human health care products. Results of this research hold the promise of developing major markets for surplus commodities.

The other major category of nonfood utilization research occurring in the Department of Agriculture is in forestry. The Forest Service is funding $14.5 million of research in this area.

Research is also underway in alternative crops research. These include such crops as cuphea, guayule, lesquerella, crambe and rapeseed, jojoba, meadowfoam, guar, safflower and kenaf. Products derived from these crops include special fats, oils, fiber, adhesives, and natural rubber. I think in your opening remarks, sir, you referred to some of those same products, and we're pleased to see that that's being recognized as a part of our current research effort.

Upon completion of my statement, Dr. Paul O'Connell from the Cooperative State Research Service will highlight efforts the Department has underway to commercialize a few of the more promising alternative crops, such as kenaf.

Let me now turn to what I consider to be the main points of the report which has been produced by the task force. The report sets forth that diversification of U.S. agriculture must become a national priority. I would like to say, Mr. Chairman, that is one of the major themes of this report in terms of general recommendations that we can use as a guideline and a benchmark for thinking for the future. It also points out that significant opportunities exist for new farm and forest products—particularly in industrial, nonfood application areas.

The report emphasizes the need to involve the private sector in the research and development on new uses. Mr. Chairman, this is an important part of the report and an important theme. I think they have reemphasized that we look to the future here. I have seen that part of the report dealing with the establishment and funding of a Foundation for New Farm and Forest Products.

While we agree with the need to continue, and even accelerate, our efforts to find new uses for farm and forest products, we cannot agree with the portion of the task force report relating to funding.

You well know the budgetary constraints which the Federal Government faces. The recommendation for the establishment of a Foundation is innovative. We will, of course, examine the proposal, but I would suggest that, as an alternative, we continue our present efforts, and seek to involve the private sector in providing research and development funds. Recent changes in Federal laws do permit such private-public partnerships.

The Federal Technology Transfer Act of 1986, Public Law 99-502, authorizes cooperative research and development agreements under which Federal laboratories may "accept, retain, and use funds, personnel, services, and property from * * * " and provide the same except funds to cooperating industrial organizations, including consortia. Such an agreement is currently being developed with an industrial consortium for cooperative research with the Agriculture Research Service's Northern Regional Research Center at Peoria, Illinois. At least four additional cooperative research and development agreements are in various stages of negotiation with individual firms interested in cooperative research with other ARS laboratories. We should seek to pursue this course of action.

Finally, Mr. Chairman, I want to commend Dr. Sampson and the members of the task force for their diligent efforts in compiling this report, and for their efforts on behalf of the American farmer and forester.

Mr. Chairman, I would also like to express me appreciation to you and the members of this subcommittee for providing this opportunity for members of the task force and other interested parties to comment on this important research. I welcome the opportunity to respond to your questions.

Senator **Conrad**. Thank you, Dr. Bentley. I very much appreciate your coming today.

Could you tell us how much the Department of Agriculture is spending every year on research, what the total research number is? Do you have that?

Dr. **Bentley**. Well, again, in research that is funded by the Department of Agriculture—that includes the Agriculture Research

Service, the grant under the Hatch Act for the Agricultural Experiment Stations, the competitive grants, and the funding in the forestry research programs that cover a broad range—it would be in the area of $1 billion, that kind of expenditure. Now, that's leveraged by a great deal more from the States as well as to the experiment stations that you are familiar with.

On that figure, I would hope that I could have the record open to check the exact figure, but let us say in round numbers, because in the cooperative program, it's added, and you sort of have to check to be sure you have your right base for the current year.

Senator CONRAD. Okay, we can leave the record open on that point.

[The information was subsequently received for the record and follows:]

In fiscal year 1987, $1,001,400,000 was available to the Department of Agriculture for research. The most recent information from our cooperators is for fiscal year 1986 when there was $966,485,000 available for agricultural research from State appropriations and other non-Federal sources.

Senator CONRAD. I think it is important that we provide for the record the answer to this question. How much of that is directed to research on new uses.

Dr. BENTLEY. Well, going back to my testimony again, the total from the Agriculture Research Service is right at $25 million for that activity. That's a part of the budget for our utilization of the utilization labs such as Peoria and Philadelphia; some textile programs in New Orleans and in Albany, California. But there are other——

Senator CONRAD. So we are talking about, out of $1 billion of research, we are talking about $25 million devoted to new uses.

As we look toward the future—let's not judge the past—but as we look to the future, is it your sense that we ought to be changing that balance in terms of our total research budget?

Dr. BENTLEY. Let me go back to make one adjustment, perhaps, in the way we look at it. If we think of the $25 million, the appropriate thing to look at for the total is the agriculture research budget, which is approximately $500 million. That's with the $25 million I speak of.

Senator CONRAD. So we are talking about—we are comparing apples to apples, in other words. We take the proper base and compare it to the $25 million, we are talking about 5 percent of our effort is going toward new uses.

On that basis, looking to the future, so we don't cast any aspersions on the past, let's look to the future. What is your sense? Ought we be changing that balance and if so, in what way?

Dr. BENTLEY. Here again we're looking to the future and giving opinions, and I appreciate the way you ask the question; it's easier to answer. I think that we should be moving in that direction. We should move to more of this if we can and the funds are available to deal with the competing demands that we have for agricultural research. Everyone feels that urgent need for products, for doing research.

I think we should move to it, and the reason I think we can is that we have some new, powerful tools to do things now that we couldn't do before. I'm thinking of biotechnology. We are, in ARS—

and I'm speaking now about ARS, but it would also be true for the experiment stations as well—are moving to the application of biotechnology and every area of their research, whether it's in crop, livestock production, soils, et cetera, but we can also apply it to new uses and sometimes we can make some dramatic changes, because of new ways of doing fermentation processes, new ways of modifying organisms, et cetera, can be used in confinement in an industrial sense.

I think we have got the chance to do some things to reduce some costs for producing and processing agricultural products. It's been somewhat of an albatross around our neck in the past because, while we could use agricultural products as feedstocks in industry, there is always a competitor out there, a number of competitors, with building products being one major source, that has been less expensive because in the processing of corn, you have got a lot of product there to dispose of and use for other purposes whether it's in corn gluten feeds or in other areas.

So I think we have got some new ways of doing it. When we have new ways of doing things, then there is opportunity for progress, and that then generates activity.

Senator CONRAD. Let me ask this: Do we have some good success stories to tell in the area of industrialization of products, products that we have successfully taken to the marketplace?

Dr. BENTLEY. Yes. There is a great deal of work that has been done on ethanol in the production of energy; it has got some problems that we know of, but that's one of the areas where there are significantly large tonnages to go.

When we think of products, we do have some specific ones that probably are not large or have large impacts on the market in the agricultural area, such as some of the activities in modifying starches, and getting some of the products that they are used in. In sanitary products, various kinds that have moisture-absorbent capacities have been outstanding examples of how you can take that beautiful molecule, starch and oils, and make it into a commercial product. Infant diapers and other things have had their value enhanced a great deal by the use of these kinds of things.

In cosmetics, the development of the so-called "superslurper" compound, which is an interesting name but——

Senator CONRAD. Why don't you tell us, so that others will know when we talk about the super-slurper compound. What is that?

Dr. BENTLEY. It is a product from carbohydrate, made from starch that has an immense capacity to take up water, to hold water. So in cosmetics it gives a certain smoothness that they can use in various products and as a fashion item, the wet look lipstick is partly due to the fact that you have this product in there that holds water and gives that appearance.

It is a marvelous compound and it has a lot of uses. It probably doesn't use many tons of corn; I wish I knew the numbers, but it's not very large compared to 8 billion bushels of corn.

That's a good example of use. Let me go to the forestry area, though, where we have had some significant tonnages in products where you can take lower quality timber products, and, through using glues and pressure, form trusses and various things that are now common in the market that couldn't be produced say 25 years ago.

Senator **CONRAD**. Were those produced as a result of USDA research?

Dr. **BENTLEY**. Yes, sir. That just came out of the laboratory at Madison, Wisconsin.

If I may add just one other thing that is creating a lot of excitement for us right now, that is taking starches, corn starch, and developing agricultural films, films that are used in agriculture as well, the black films that are used in vegetable production that increase soil temperatures, and are used extensively to control weeds. The amazing thing about that, Mr. Chairman, is that they can mix in a type of polymer from petroleum and have various mixtures. It will degrade over roughly a 30-day period or a 60-day period or a 90-day period, so you have some biomass or a natural system for disposal of the film, which has been a great problem, as you know, with the various films that we have used in agriculture before, and we had such large volumes of it.

Senator **CONRAD**. So what you are saying is that this product can be developed in a way that allows it to be biodegradable?

Dr. **BENTLEY**. Yes, it does.

Senator **CONRAD**. So you not only have the benefit of the first use but you do not have the negative of something remaining as residue which you didn't want. Is there any advantage—once that does break down, that it adds something to the soil, or is that a neutral?

Dr. **BENTLEY**. I would think it would be neutral; it would be organic matter from the starch, and since the starch is so well liked by microorganisms in the soil, they would break it down rather quickly.

Dr. O'Connell will be talking about some specifics that we are looking at in terms of oils, special vegetable oils, special oils for soaps and other purposes that are now being imported and are now in demand by companies looking for improvements in current products that we use. The kenaf paper substitute for some papers used for printing which we import, I think a substantial percentage of it right now——

Senator **CONRAD**. What is kenaf?

Dr. **BENTLEY**. Dr. O'Connell will talk about it. It's a plant that is related to cotton. I believe it is an annual that can be grown well, particularly in the Southern regions of the United States, where it responds well to warmth, and day and season length; but up in the States where we grew up, it wouldn't be a big crop. It is a fiber-type plant that can be processed into making paper.

Senator **CONRAD**. Let's develop something like that that would grow well in North Dakota. Can we do that? [Laughter.]

Dr. **BENTLEY**. I was afraid you were going to ask that.

Well, there are possibilities. Rapeseed, as some of these plants are modified, can be grown there. Of course, we have strong competition in this area from Canada, and we should not be surprised to have competition in these areas, because each area is trying to find a crop that will fit their particular set of circumstances.

Senator **CONRAD**. Canada has been very aggressive.

Dr. **Bentley**. Yes, understandably so, because erucic acid, which again will be discussed a little bit later, is to be used in making plastics and plasticizers, and all of these kinds of things.

Senator **Conrad**. I want to tell you, I was just on a French farm a week ago; and on that farm they are growing wheat and corn, peas, and they were growing rapeseed. And they have been aggressive as well.

Dr. **Bentley**. In talking about rapeseed, I was on an international science body a few years ago, and one of the achievements the head of the Canadian research program reported on was modifying the plants to get away from the compound that causes blisters in pigs, especially pigs with white skin. They blistered, and they have taken that out through a breeding process; and that has enhanced the quality of the rapeseed.

Now many of these things, we have known we can grow them for some time, and there has been research on them in experiment stations, but especially ARS. The price relationships change all the time, and that makes such a big difference when you talk about bulk commodities.

Senator **Conrad**. Let me ask you one last question, and then we will proceed to our other witnesses.

Could USDA effectively, in your judgment, use additional funds for the commercialization of new products? If so, what order of magnitude are we talking about? What kind of research dollars and what kind of dollars for commercialization in your judgment could be effectively used in the future?

Dr. **Bentley**. I think the question is in two parts, if I may answer it in that way. Could we use additional funding? The answer would have to be yes, because there are ideas that are on the drawing board that could be studied, especially if you get down to what we might call the more fundamental type of studies; that is, looking into biotechnology and how can you modify a plant or modify the genetic material to cause a plant to produce the kind of product or kind of proponent in a product that is needed for industrial purposes rather than producing starch and oil that are considered in the food use sense. There may be uses in foods.

There are still a lot of industrial uses of fats and oils, soybeans and corn, particularly. Now how much, when you talk about budget, that's one question, but I would like to answer it saying "how much could be used."

Senator **Conrad**. Cost effectively.

Dr. **Bentley**. Cost effectively, I guess I have been through these quite a few times. If we could get some increases that are needed right now something on the order of 25 percent of this could be rather effectively used, but not on a crisis basis, a crash basis. I think you need to build these up—and I am speaking now not necessarily as an official of the Department, but as a person who has had to administer research for a good many years——

Senator **Conrad**. Well, as soon as you're done. [Laughter.]

Dr. **Bentley**. My feeling is that if we had increases sustained over a period of time, what we need is something that says we have got 5- or 10-year commitments to these things and not knee-jerk reactions.

Senator **Conrad**. What you need is sustained——

Dr. **Bentley**. To defend some of my colleagues whom I think sometimes have been unfairly criticized, and that was before I was an official member of the Department, while I was dean of agriculture at Illinois; we had a time when there was a sustained development that led to kenaf and some of the things in oils, and then we went through a period of time, and I don't wish to get any political connotation to this, but a period of time when they were admonished to quit doing research in——

Senator **Conrad**. Was that in a recent period of time?

Dr. **Bentley**. No, but I am thinking about the policy and the philosophy where it said that we went through a period of time when that was postharvest technology, that the public research should not be used for that particular purpose, so we slacked off on that, and the $25 million that we have is a bit of the residue from that activity. I can't give a figure now whether that would be more or less proportionate to 10 years ago, but there was a sustained project.

We were looking at new crops and new plants; we had an extensive program in Peoria, I think one of the best that has ever been done in this country, looking at crops. I will state that we had to pull back from that; not completely, but we pulled back from it a bit, and that's what I think we now should be considering and that's what my colleagues would all agree. We need to start the sustained growth.

Now, how much, and what mechanism we use at a given time of course, is something that we have to work out with the Executive and the Congress.

Senator **Conrad**. That was going to be my last question to you, but you triggered another question; and that is, what role should public-private partnerships play in this research. In other words, we can have research that is purely governmental; obviously there is always going to be research that is purely private. How much that is publicly funded ought to have a public-private component? Should every bit of research that is done have a public-private component or should we be expecting the public sector to do the more basic research and when we get to commercialization, have a public-private involvement? What is your notion of the structure of the research?

Dr. **Bentley**. Well, as you properly describe, research is a continuum, and there's some research that we can call fundamental or basic or high risk or investigating to find out if there's any potential there, and I think that's what the Government ought to do on a sustained basis, to find out, for example, if somebody has the idea that we might modify a wheat plant to make it produce something else in addition to or something else other than the starch and the things that we use in bread wheats, make a new kind of wheat.

That is a pretty far-out idea. Maybe we ought to have research that will sustain that. As I see it, even here it should have an element of understanding that the market potential for something exists—that is, you are going to create something, maybe it needs basic research to get there, but there ought to be some land use products, some idea that we are getting there.

Now as we go down the line, I think that the future contains for instance, more and more public and private cooperative ventures, particularly in making decisions about the market; what is the product? I think I speak for all of our research activities in agriculture; we are not really set up to understand the market forces and the development side. That's not our forte, but we can contribute to that, because who better than the person that did the basic research on something would be able to talk with the developing side, the D side of the R&D, about what could be done.

I think that is the partnership, and I personally am trying to help foster such ideas. Now, it is not easy. People speak of this and we have been talking about these terms for many years, but we need to find mechanisms for getting it done, making it easier for the private sector, but also easier for the public sector. There are a number of things that have to do with philosophy of research, with the whole idea of technology transfer, patenting, how do we share an intellectual property, how do we protect the rights in the public and private sector, all things that need to be done and they are not as easy as they might seem to be, too; and yet I feel in the last 2 years, there has been a great deal of progress. Perhaps biotechnology has helped us do this, realizing how fast we go. But we're in superconductivity; and if we don't find the mechanism to cooperate in that, I think that it will be to the detriment of the United States.

Senator CONRAD. Thank you very much for your testimony, Doctor. We look forward to working with you in the days ahead.

Dr. BENTLEY. Well, I do, too.

Senator CONRAD. Thank you very much.

My thought is that we would next hear from Dr. O'Connell, not quite follow the structure that is in front of us, and then go to the New Farm and Forest Products Task Force as a panel, so that we could hear from all of you together and have a chance then for questioning.

Why don't we proceed with Dr. O'Connell, who is the Deputy Administrator, Office of Grants and Programs Systems of the Cooperative State Research Service.

Dr. O'Connell, welcome and thank you for coming, and we are interested in hearing your testimony.

STATEMENT OF DR. PAUL F. O'CONNELL, DEPUTY ADMINISTRATOR, OFFICE OF GRANTS AND PROGRAMS SYSTEMS, COOPERATIVE STATE RESEARCH SERVICE, U.S. DEPARTMENT OF AGRICULTURE

Dr. O'CONNELL. Mr. Chairman, it is a pleasure to be here and to talk about this topic that I have been involved in for some time, but especially in the last few years.

Mr. Chairman, Assistant Secretary Bentley has told you of some of the activities of the U.S. Department of Agriculture related to the development of new uses for farm and forest products. As the Deputy Administrator for USDA's Cooperative State Research Service, my office, in cooperation with the Agricultural Research Service, the Nation's land-grant colleges and universities, other Federal agencies, and the private sector, is directly involved in a number of research and development projects designed to bring about new and innovative uses, particularly industrial and nonfood uses, of American agricultural products. I am pleased to provide this subcommittee with a brief overview of these projects.

I will comment on a few of these demonstration projects that we have underway, and I think it relates to the topic you were talking about earlier, about infrastructures and working relationships that we are getting started in this area.

The first one I would like to talk about is the kenaf demonstration project (newsprint). This was initiated in 1986 with a cooperative agreement between the Cooperative State Research Service and Kenaf International. By the way, Kenaf International is a private firm and the Food Security Act of 1985 allows a Federal agency to enter into a cooperative arrangement with a private party without competition—after certain requirements are met. Prior to the Food Security Act of 1985 that possibility did not exist. It is a very important tool for commercializing new technologies and crops.

Senator CONRAD. When you enter into, if I could just stop you there, when you enter into a joint venture, what happens to the open records laws and that kind of thing? How are you able to preserve the commercialization potential, and how are they assured that they are not promoting a project that is going to be spread before the world the next day in the newspaper?

Dr. O'CONNELL. Well, in the case of kenaf, really the people that were involved here, at least from the standpoint of both the production and the processing end of it, they aren't real concerned about the patenting and exclusive rights and so forth, but their main concern is getting in on the ground floor. In other words, being the first ones in the industry.

In this particular case that was not an issue, and as we have gone along, that has not been an issue. Really what is involved here is to get this area started. In this particular case, Kenaf International had grown a fair amount of seed and they quite frankly have the only major supply of seed.

Anyway, we entered into a cooperative agreement with Kenaf International, and our objective was to demonstrate the economic viability of kenaf as a fiber of choice for use in manufacturing newsprint—a commodity we currently import at a cost of $3 billion annually. The use of this crop will not replace wood chips as the major raw material source, but in some markets there are price and quality advantages. Kenaf uses less ink, results in whiter paper, and requires less energy for processing. The growing area for kenaf is across the southern tier of the United States.

Senator CONRAD. Not North Dakota?

Dr. O'CONNELL. Not North Dakota. [Laughter.]

As Dr. Bentley indicated before, I don't think it would compete very well.

State-of-the-art fiber handling, pulping and newsprint manufacturing technologies developed under the project are being applied in commercial paper machine and pressroom runs. We are doing this right now. Over the past year we have been working on actually developing technical data for this crop in cooperation with the industry. The data that the researcher has, that he gets out of his project and the pilot tests is not quite in the form that the manufacturer can take to a financial lending firm.

So you have to develop technical data that the private sector and the people they have to get financing from are comfortable with. They are plant managers, marketing people, and so forth. They know that this information is something they can depend on.

So right now we have commercial runs going on, and we will be able to show to you within a couple of weeks or a month a Wall Street Journal that will be published with kenaf.

Senator **Conrad**. Will it improve the editorial content? [Laughter.]

Dr. **O'Connell**. I'll let you be the judge of that.

Evaluations of these commercial runs are expected to affirm acceptance of the kenaf newsprint system from seed production to daily newspapers, and that is the key point here.

Large-scale kenaf farming for newsprint manufacturing is not expected until the 1989 or the 1990 growing seasons. Until this time, project work will focus on conversion of process capacity at existing mills, product testing and evaluation for noncompeting markets in the firelog and carpet felt industries, improvement of harvest and fiber handling methods, and extended growing trials in selected areas.

This is an important element of any one of these new ventures: to look at the byproducts. I am talking about the byproduct aspect of kenaf here. I don't care which one you go into, you have to look at all of the elements of potentially marketing a particular product. That way, you're really getting at the economic viability question; because you're not likely going to do it just on the basis of the main product alone.

Another project that we have underway, and you commented on this in your opening statement, is in regard to guayule. This crop can provide an alternative source of natural rubber.

Senator **Conrad**. Is that the proper pronunciation? You noticed that I didn't even attempt it. [Laughter.]

Dr. **O'Connell**. It's guayule.

Senator **Conrad**. It starts with a G, and——

Dr. **O'Connell**. You have not lived in the Southwest United States, I can tell.

Senator **Conrad**. You're correct.

DEPARTMENT OF DEFENSE/USDA GUAYULE AGREEMENT (RUBBER)

Dr. **O'Connell**. A 27-month Joint Guayule Domestic Rubber Project was signed in 1986, and this was with the Department of Defense and others.

Under the agreement, the Department of Defense is providing $11.1 million in funding over the 27-month period, and from this amount, $1.3 million is targeted for shrub production and maintenance at the Gila River Indian Community [GRIC] in Arizona. This is in Sacaton, just south of Phoenix. In April 1987, under an $8.3 million contract, the Firestone Tire and Rubber Company broke ground to build and operate a prototype processing plant for removing the rubber and byproducts from the shrub being grown at Gila River Indian Community. We had the groundbreaking ceremony down there in April.

Senator **Conrad**. Has an analysis been done of where the breakpoint is between where oil prices have to be?

Dr. O'Connell. Yes. The Department now has been involved primarily on the economic side and somewhat on the processing side over the last 5 to 6 years, since the passage of the Critical Materials Act.

Early in that development, they did some economic studies, and we have done economic studies since then. A few years ago the price of rubber was up around 80 cents a pound, and it looked like it was approaching an economic breakpoint. Now of course the price of natural rubber is down around 40 to 45 cents a pound, so it does not look that feasible.

The key thing we need to do with guayule is, to get the percent of rubber in the guayule bush up to a higher level. Now when they started on the breeding program about 5 to 6 years ago, we were talking about the percent of rubber in guayule being 4 to 5 percent. We are now looking at varieties that are around 8 or 9 percent.

There also is a byproduct of the guayule plant called resin which has economic value, and there is a commercial value out there for that product. But what we feel we need to look at is looking toward the possibility of—and until we can get there—is something on the order of 14 to 15 percent of rubber within the plant.

When you look at the potential of guayule you need to look at what's happening with corn. That would not be an economical plant when we first grew the native plant. The same is true with guayule. So we feel with guayule and including the byproducts, that we are working toward, a point where we can be competitive, even at 40 cents. We're looking down the road 5 to 10 years in the future. With the combination of traditional plant breeding and biotechnology research we can get to a point where we will be competitive.

The reason the Defense Department was interested in guayule is for strategic purposes. They don't want to be cut off from a natural rubber supply like we were in World War II. Most people don't realize that we simply have to have a source of natural rubber. You can't land planes with synthetic rubber tires. You have got to have natural rubber tires. Synthetic rubber tires just do not have the same heat resistance as natural rubber does.

One reason that the radials that you have on your car last longer is because they have a fair percent of natural rubber in them.

Senator Conrad. No radials on my car.

Dr. O'Connell. But nevertheless, we have to have natural rubber; we cannot be totally dependent on synthetic rubber.

We have a contract with the Firestone Tire and Rubber Company as a part of this, again showing a working relationship with the private sector.

The goal in this operation in the next 27 months is to produce about 50 tons of rubber for exploring commercial opportunities and tests to see if the rubber meets the Defense Department's standards of heat-resistance and durability. They have standards for their tires, so we're going to have about 10 tons that will be used by them to test and see if they meet their particular needs, and with the rest of that rubber we will be looking at commercial opportunities. A significant part of this project is that the Department of Defense has agreed to purchase up to 20 percent of its annual tire rubber requirements depending on the results of the tests of the prototype operation. In other words, we have that arrangement with them; the Department of Agriculture and the Defense Department.

That will allow us, then, to develop a market and move in the direction of having guayule commercially viable.

USDA will utilize an additional $1.5 million of DOD funds for technical assistance and cooperative agreements with universities and others to strengthen R&D efforts.

Within the same time period, the USDA, in partnership with the State Agricultural Experiment stations, will provide an additional $4.5 million for guayule research. This research addresses plant breeding and genetics to improve rubber yield, agronomic problems, and utilization of plant byproducts for value-added end uses by industry.

So that's another exciting project that we have underway, working in a cooperative arrangement, both with DOD and industry.

CRAMBE/WINTER RAPESEED (HIGH EURIC ACID)

Another project which is a little more dear to your heart is crambe/winter rapeseed (high erucic acid). A planning conference was recently held as a cooperative effort sponsored by the Department of Agriculture, Iowa State University, Kansas State University, and the University of Missouri. Conclusions of that conference provide evidence that the current erucic acid oil markets rely on foreign sources, but we feel that the production technology that we have and can develop is sufficiently promising that a domestic production system can be established.

Uses of high erucic acid includes slip agents, lubricants, plasticizers, and nylon fibers. A strategic plan is being developed for directing efforts, with private industry providing input on developing the most promising new products and markets.

The main focus of this project is to look at the markets that are potentially there, to work specifically with private industry and firms that are buying this product now or potentially could buy this product, again for the purpose of developing technical data they are comfortable with.

In other words, we feel it's critical that we put the emphasis on this area rather than putting too much emphasis on the production.

HYBRID/STRIPED BASS [HSB] DEMONSTRATION PROJECT

Another project that is not an industrial crop, but it indicates the type of opportunities we are exploring is the hybrid/striped bass [HSB] demonstration project.

Senator CONRAD. Repeat that?

Dr. O'CONNELL. Hybrid/striped bass. A related name for it is rockfish. It is a fish species that is currently under moratorium in the Chesapeake Bay; in other words, you can't fish for it right now, because there just isn't enough.

What we are looking at here is something that we would grow on the farm; farm-grown fish, similar to the sort of thing being used for catfish production that we are currently selling.

The project is intended to demonstrate the economic viability of hybrid striped bass farming as a crop alternative for east coast farmers and watermen. Midwest production is also a possibility.

East coast populations of striped bass have declined and most

Coastal States have prohibited fishing. The seafood industry is seeking alternative sources and farmers are seeking production alternatives. Production is intended to fill a market void at a premium price.

PLANS

The plan we have in this particular project is a small, ongoing research project on the Eastern Shore of Maryland which will be expanded to a production level demonstration farm for hybrid striped bass using the expertise of Federal, State, university, and private interests. Approximately 30 acres will be involved initially and will produce at least 60,000 pounds of fish on 24 water acres. Production costs are estimated at about $1 to $1.50 per pound, and the current New York price for larger striped bass is about $4. Market areas will be identified, and a private marketing firm has agreed to work with us to handle the marketing and contribute to market tests.

One significant part of this project is that we have worked out an arrangement with Campbell Soup Company, who is willing to work with us on the processing and marketing side. They have a tremendous network of knowing how to market, much better than we do; and they are planning on joining in with us to explore the packaging, the distribution, what sizes should be grown, et cetera.

As you may know, Mr. Chairman, we now have about a $3 to $4 billion net trade imbalance for edible fish products. In other words, we export about $1 billion and import about $5 billion.

Senator CONRAD. That disparity, I understand, is growing rapidly.

Dr. O'CONNELL. That is correct.

You know, we had a tremendous increase in per capita consumption, and for fish products it has increased about 50 percent from 1975 to 1985.

So we are talking about some major changes in the diet. What we are looking at here is one possibility for the farmer to get in on a new opportunity. The market is there, and it's growing.

Senator CONRAD. Can we convince these fish to eat corn and wheat?

Dr. O'CONNELL. That is right; they will eat those. They eat soybean products, corn, and this is something that people need to realize.

Senator CONRAD. So this has the potential to be doubly beneficial.

Dr. O'CONNELL. Correct.

Mr. Chairman, I thank you for giving me the opportunity to appear before you and the members of this subcommittee today, and I will be pleased to respond to your questions.

Senator CONRAD. First let me thank you for your testimony. Let me go back to the question that I was exploring earlier, and ask you the same thing: In your judgment, for the future, ought we be changing the mix of our research dollar and putting more of our emphasis in the development of products, alternative uses, and if so, to what degree? What do you see as the need for additional research dollars, and do you agree precisely with the previous witness?

Dr. O'Connell. He's my boss.

As was discussed earlier, I think it is very important to have a continuum here. I think in many of these areas—you see, the areas that I talked about, like kenaf, and also striped bass, let me just use those two examples—we felt that the research is to the point that we could start working with the private sector and saying "Hey, let's see if this thing really is ready for the market," and work with them. This was done not on a short term basis; this was done after a fair amount of investigation with them, people coming together in a work conference and this sort of thing.

So there are some technologies out there right now that we need to look at and to try to commercialize. There are other areas, just like we indicated with guayule, where we have really got to have a breakthrough in the ability of this plant to produce the products that we want.

In that particular case, we are going to have to have some fundamental research going on, we are going to have things happening here at the basic research level, and so where I am coming from is that we need to have this total continuum. To answer your question more directly I would support what Dr. Bentley said before—we do need to have more emphasis at the commercialized end of the continuum.

I think that situation exists not only in agriculture, but in most sectors of the economy. We have not done quite the job we should; and it's not just resources. It is a matter of attitude, institutions, and the way we approach these matters in the total society.

Government and the private sector don't trust each other. There are many barriers we have got to overcome here. Some of them Dr. Bentley already mentioned. But I have found in these projects, that I have been involved with now for a couple years, is that once you get out there and you set up a working group that involves the processing people, the marketing people, the people from academia; and you get working together, these perceived fears fall by the wayside real quickly; and you develop a common goal. In the case of kenaf it has gone along better than anyone anticipated. It was built on 20 years of research, but the commercialization aspect didn't occur until a joint private/Government venture was started.

Many aspects of this project make it very interesting. Kenaf International, who is the venture capitalist out there, had worked about 5 years in developing a seed supply. We couldn't do anything because we didn't have a seed supply. So it is these kind of things that build one on the other, and so I would say yes, that there needs to be more emphasis, as Dr. Sampson indicated the other day, on passing the baton from research results to a final marketable product.

Senator Conrad. Thank you very much. That is valuable testimony.

I think what we will do is ask Dr. Sampson, the Chairman of the New Farm and Forest Products Task Force and the other members who are here; Jeff Gain, chief executive officer of the National Corn Growers Association and Dr. Gary Jolliff, professor of crop sciences at Oregon State University.

If you will feel free to stay there, maybe after we have heard their testimony and we get into the questions, we might have some exchange here that would be valuable. If you can stay; if you can't, we understand.

Dr. **Bentley**. Mr. Chairman, it is my intention to stay.

Senator **Conrad**. Good.

Welcome. It is good to have you here this morning. Why don't we just start with Dr. Sampson, who is the Chairman of the New Farm and Forest Products Task Force.

We have the publications before us that have been produced, and this is an exciting opportunity. I am very excited about the prospects of where we are going and the opportunities that lie before us. I think there has been exceptionally good work done here, and I want to applaud those of you who participated in this effort. This is exactly, in my judgment, what we need to be doing in this country, and need to be doing more of it.

So I very much welcome you here today. I want to applaud the efforts you have already made, and tell you that I think it's very exciting.

STATEMENT OF DR. RONALD L. SAMPSON, CHAIRMAN, NEW FARM AND FOREST PRODUCTS TASK FORCE

Dr. **Sampson**. Thank you, Mr. Chairman.

Mr. Chairman, members of the subcommittee, I am both honored and pleased to be invited to come before you on behalf of the New Farm and Forest Products Task Force. I am of course joined by two of my colleagues from the task force whom you have also invited here today. Although I will be speaking as chairman of the task force, my comments will be presented in the context of a private industry viewpoint. Professor Gary Jolliff, of the crop science department of Oregon State University, will speak from his view in academia, while Mr. Jeff Gain, chief executive officer of the National Corn Growers Association, will provide additional private sector perspective, particularly from the producers' position.

Mr. Chairman, I do have a prepared statement which with your permission I would like to have entered into the record in its entirety.

Senator **Conrad**. Absolutely, and that will apply to all of you. We will enter your full statements into the record, and however you would like to present your testimony is fine.

Dr. **Sampson**. Thank you, Mr. Chairman.

For the last 2 years, the New Farm and Forest Products Task Force has been addressing issues related to agricultural challenges and opportunities. Our task force has been a collaborative private-public sector effort under which each member has voluntarily devoted both time and energy. In some cases, this has involved considerable personal expense and personal sacrifice.

Let me underscore this point: The New Farm and Forest Products Task Force has been comprised of a group of individuals with diverse backgrounds and interests, whose coordinated vested interests were brought together to deal with issues that are vitally important to the entire Nation.

Indeed, we have joined together to undertake our demanding task, because we each share the belief that the issues that we are addressing are vitally important to the interests of the entire Nation.

Although our group has enjoyed the support and encouragement of the Department of Agriculture and many sponsoring organizations including companies and universities, our task force has always been an independent body. Consequently, the views and recommendations we offer do not necessarily represent those of the Department of Agriculture or any specific sponsoring organization.

However, yesterday, we did report our findings to the Secretary of Agriculture, and we do welcome this opportunity to review them with you here today.

We see agriculture as not only the Nation's largest industry but also a strategically vital one upon which America's security, international competitiveness and prosperity largely depend. Consequently, we believe that realization of the full productive and economic potential of the agricultural industries is a critical national need.

Although we admit it is a somewhat simplistic view, the current stresses faced by agriculture might be viewed as a consequence of an overconcentration of production in a relatively few major food and feed crops, ones which promise to be in continuing global oversupply.

Indeed, current trends suggest that the challenges American agriculture will face in the future will be even greater than those faced today, unless effective action steps are taken now. These steps are essentially for America to lead the world in agricultural innovation.

More specifically, our findings have led us to conclude, as Dr. Bentley mentioned, that diversification of agriculture and forestry must become a national priority. By diversification, we mean that new crops and new uses for existing ones must be developed to meet real market needs.

Emphasis must be placed on the development of those products which will present net new demand for agricultural production. Importantly, our investigation did lead us to conclude that such opportunities do exist, particularly for new agricultural products to meet industrial needs.

We have embodied our conclusion in a proposal for a specific national diversification goal. Specifically, we propose that the Nation undertake the development and commercialization of new farm and forest products which present net new demand for agricultural production equivalent to that of two to three new soybean crops within the next 25 years.

Now this is a very recent goal, which will require many more than three new crops to be realized. However, the members of the task force firmly believe it is one that can be achieved if the national will exists to accomplish it.

We project the payoff for success to be substantial. We estimate that $30 billion could be added to farm income and $100 billion to national economic activity as well as 750,000 net new jobs by such successful achievement of that goal. Yet such results will not happen without an appropriately structured and adequately supported program to achieve it.

In our report, we have outlined and recommended appropriate strategies and action steps and initiatives to achieve this goal.

For the record, I would like to offer for your consideration our report, which is entitled "New Farm and Forest Products—Responses to the Challenges and Opportunities Facing American Agriculture."

Although we propose several action steps and initiatives, we consider one to be of paramount importance. Specifically, it is important that we recognize that diversification of agriculture is an old, not a new idea. However, past success has been limited for a variety of reasons.

Based on our analysis, our primary recommendation is intended to overcome some of the major limitations and constraints in past success. These constraints essentially involve organizational advocacy limitations, and the lack of continuity in dedicated, long term funding.

Our specific proposal to address these major past limitations involves the establishment of a Foundation for New Farm and Forest Products. We propose that the Foundation be specifically charged with responsibility for achieving the diversification goal. Under our proposal, the Foundation would be structured as an independent, nonprofit entity which would bridge between the private and public sectors to facilitate and cooperatively fund the development and commercialization of new agricultural products.

Importantly, the foundation would be funded through the establishment of a substantial Government trust fund primarily to provide risk investment capital over a 20-year period.

In developing the Foundation concept, the task force analyzed many prior studies, historical experiences, and several organizational models of relevance.

Accordingly, our proposal is based upon proven operational models, and does address many identified constraints and past successes. Based on our work, we believe the establishment of an entrepreneurial, independent but accountable champion organization is vitally important.

Stable, long-term funding is also needed, and that requirement underlies the basis for a recommended trust fund approach. Given the enormous magnitude of the task to diversify agriculture, the need for a relatively large trust fund which can generate approximately $75 million in investible funds annually is indicated.

Importantly, the vast majority of these funds would be leveraged with private sector and other public sector funds, to encourage long term cooperation and to share risks.

Although we have proposed establishment of such a fund through the sale of Government-owned commodities over a 5-year period, the approach to funding is not as critical as the end result.

We recognize that today's environment of fiscal stress makes such funding proposals particularly controversial. However, we members of the task force feel compelled to define what we believe is needed; and we do believe that unless we begin to now take the steps to meet the challenges of the present, we are likely to face even more grim realities in the future.

However, we members of the task force are optimistic because we sense that powerful forces of change are now converging to suggest that at long last, diversification of agriculture is an idea for which the time has finally come.

We can only hope that in at least some small way our efforts will serve to catalyze actions which will result in full revitalization of American agriculture and full realization of the great contributions that agricultural industry can make to our Nation's competitiveness and prosperity.

I thank you for the opportunity you have provided for us to share our views, and I would be pleased to address any questions you might have.

[The prepared statement of Dr. Sampson and the report, entitled, "New Farm and Forest Products—Responses to the Challenges and Opportunities Facing American agriculture" follow:]

STATEMENT OF DR. RONALD L. SAMPSON, CHAIRMAN, NEW FARM AND FOREST PRODUCTS TASK FORCE

Mr. Chairman, members of the Subcommittee, I am both honored and pleased to be invited to come before you on behalf of the New Farm and Forest Products Task Force. I am of course joined by two of my colleagues from the Task Force whom you have also invited here today. Although I will be speaking as Chairman of the Task Force, my comments will be presented in the context of a private industry viewpoint. Professor Gary Jolliff, of the Crop Science Department of Oregon State University, will speak from his view in academia, while Mr. Jeff Gain, Chief Executive Officer of the National Corn Growers Association, will provide additional private sector perspective, particularly from the producers' position.

For the last two years, our Task Force has represented a collaborative effort between both the private and public sectors. Each member of the group has voluntarily devoted both time and energy to our work and, in some cases, this has involved considerable personal sacrifice. We have joined together in such a task because we each have shared the belief that the issues we have been addressing are vitally important to the interests of the entire Nation.

Although our group has enjoyed the support and encouragement of the Department of Agriculture and the participation of each member has been supported by a sponsoring organization, our Task Force has always been an independent body. We have reached conclusions and developed recommendations which are based upon our own independent investigations. Consequently, our views and recommendations do not necessarily represent those of the Department of Agriculture or any specific organizational sponsor.

Through a rather far-reaching program of investigation and analysis, we have been probing beyond the headline issues to develop both an understanding of, and appropriate responses to the challenges and opportunities faced by American agriculture, including forestry. Yesterday, we reported our findings to the Secretary of Agriculture, and today we welcome the opportunity to review them with you.

Throughout my remarks, you might notice that I avoid use of the word, "problem". It may be subtle semantics, but the vocabulary of of innovation includes the words "challenges" and "opportunities", but not "problems". Among other things, successful innovation in any field is dependent upon commitment, confidence and optimism - and the ability to not be overwhelmed by problems. Accordingly, successful innovators view problems as merely "opportunities in disguise". Since we members of the Task Force are looking toward agriculture's future with both confidence and optimism, we have acknowledged the challenges, but we remain focused on the opportunities.

In itself, the New Farm and Forest Products Task Force actually evolved as a response to the challenges faced by American agriculture and forestry. As a follow-up to a 1984 Secretary's Challenge Forum, our Task Force was formed at the invitation of the Secretary of Agriculture to continue the dialogue begun at that Forum.

Very early, we adopted a mission to define and propose meaningful and actionable initiatives to: revitalize ailing sectors of agriculture; and help ensure that agriculture and forestry will be cornerstones of future American competitiveness and prosperity.

Through our work, we found that the agricultural situation is not unlike that of other American industries facing economic distress and competitive challenge. However, agriculture is the nation's largest industry, and quite arguably the most important one. Indeed, we members of the Task Force see agriculture as a strategically vital industry upon which America's security, international competitiveness, and prosperity largely depend. Consequently, we believe realization of the full productive and economic potential of the agricultural industry is a critical national need.

Although we admit that it is a somewhat simplistic view, the current stresses on U.S. agriculture might appropriately be viewed as the consequence of an overconcentration of production in a relatively few, major food and feed crops - ones which promise to be in continuing, global oversupply. Indeed, the future looks to be one in which an increasing number of exporting countries are competing for shrinking global import markets. These observations suggest that the challenges American agriculture will face in the future will be even greater than those faced today - unless effective action is begun today to enable us to become the masters of change, rather than the victims of it. By this I mean, America must lead in agricultural innovation, not follow.

The findings of our Task Force have led us to conclude that diversification of agriculture and forestry must become a national priority. By diversification we mean new agriculturally-based products must be developed and commercialized to meet real market needs. Such new products would encompass both new crops and new uses for existing ones. Products for applications which represent net new market demand for agricultural production, such as those for industrial raw materials, are of priority interest. Importantly, in our investigations we did find substantial evidence that such opportunities do exist for new agricultural products to meet market needs.

We have embodied our conclusion in a specific proposal for a national diversification goal. Our proposed goal specifies the development and commercialization of new farm and forest products which present net new demand for agricultural production equivalent to that of two to three soybean crops. We propose that a program be initiated to achieve this objective within 25 years. Although such a period is less than half the time it took for the soybean to rise to its current level of importance, the current existence of many identifiable opportunities provides a basis for optimism. Even more significantly, biotechnology now promises to provide the means to enable future advances in agriculture beyond what could have possibly been imagined just a few years ago.

In this regard, it is worth remembering that agriculture is an industry fundamentally based on biology. Much of the historical progress made in agriculture has been made through the genetic manipulation of plants and animals - albeit in a random and relatively uncontrolled manner. Nonetheless, agriculture has achieved a remarkable record of unblemished, socially responsible progress through such biological manipulation.

New biotechnologies, particularly genetic engineering techniques such as recombinant-DNA, promise to provide the means to dramatically transform future agriculture in terms of both efficiency and diversity. The fact that the United States currently is the world leader in biotechnology suggests we are well positioned to lead in agricultural innovation through biotechnology. However, overseas competitors are not far behind, and inordinate delays in applications of these new technologies, because of regulatory and legal complexities, could cause us to become laggards, rather than leaders, in the use of our own technologies.

Although the current level of attention being devoted to such issues is reassuring, we must recognize that our future progress will depend upon our ability to efficiently and effectively balance legitimate social and ethical considerations with pragmatic technical and economic ones.

Returning to consideration of the diversification issue, we members of the Task Force acknowledge that the goal we have proposed is a very reaching one. However, we firmly believe it is one which can be accomplished -- if the national will exists to achieve it. Such an undertaking will, of course, require a substantial and enduring commitment in the form of effective, and well-supported initiatives. In our report, we have outlined and recommended appropriate strategies, action steps and initiatives to achieve this goal. For the record, I would like to now table this report, which is entitled: "New Farm and Forest Products: Responses to the Challenges and Opportunities Facing American Agriculture".

Although we propose several action steps and initiatives, we consider one to be of paramount importance. Specifically, we propose the establishment of an appropriate organizational entity specifically charged with responsibility for achieving the goal, and provided with adequate funding and other resources needed for success. We have titled our proposed entity as the "Foundation for New Farm and Forest Products".

As conceptualized, the Foundation would be an autonomous, non-profit entity which would bridge between private and public sectors to foster and facilitate the development and commercialization of new farm and forest products. Importantly, it's roles would include that of a cooperative funding source for collaborative private/public sector developmental projects.

The Foundation concept is based upon much prior study and analysis, and builds upon proven organizational models throughout the world. It is described in some detail in our report, and proposed draft legislation for its establishment is included in the appendix to our report.

We recognize that, within the Congress, there already is a high level of awareness of, and interest in the development of new agricultural products. This is evidenced by the introduction of relevant legislative proposals in both the Senate and the House of Representatives. Although we find the existence of such legislative initiatives most encouraging, we believe it would be useful to draw to your attention some important distinctions between our proposal and those already under consideration. For the purposes of this comparison, I will confine my comments to two principal aspects: (1) organizational structure; and (2) funding.

Our proposal differs from others under consideration because it proposes the establishment of a separate, independent yet accountable, organizational entity. We believe that the establishment of a separate entity specifically being charged with responsibility for reaching the diversification goal is a prerequisite for success. In our view, to be effective in marketplace interfaces, such an entity must be outside of the operations and direct administration of a government department or agency. This view is based on the following two specific considerations.

First, as a general principle, any substantial goal can only be achieved if a properly structured and supported organization is established with a dedicated, single-minded mission to reach the goal. Dilution of the focus of the organization through the existence of divergent goals and purposes compromises its ability (and its accountability) to attain the goal. Such dilution is appropriate if no single goal is of sufficient importance, or the task to achieve it is not of significant magnitude. However, attainment of the agricultural diversification goal is a major undertaking with regard to both its national importance and the magnitude of the task. Under these circumstances, a dedicated "champion" organization seems not merely appropriate, but essential.

Second, although the proposed task may well be somewhat comparable in importance and magnitude to prior national energy and space efforts, diversification of agriculture differs markedly from such precedent programs. The proposed agricultural effort is intended to deliver new products which meet real market needs. Consequently, it must be market-driven and responsive to market requirements. This consideration alone suggests that primary responsibility should rest outside of direct operational control by the government. It also suggests that the people who manage and operate the organization should be largely drawn from the private sector, and should function, as much as practicable, under conditions of private sector expectations and incentives. This implies emphasis on "bottom-line" results and rewards based upon results.

This latter point does not imply that we suggest a lesser degree of public accountability. On the contrary, accountability is an essential part of the concept. This accountability of course relates to proper control of expenditures and funds, but it also relates to accountability for performance in terms of goal achievement. Autonomy in operations is quite consistent with accountability for financial control, and it is essential if there is to be accountability for results.

Our emphasis on a private sector approach does not ignore the existence of a great many dedicated and capable people in the public service. However, it does recognize that the functional roles, skills and experiences of career public sector people do differ considerably from those in the private sector. Since the proposed diversification program is oriented toward meeting market needs and facilitating the development of profitable enterprises, the need for strong private sector leadership is indicated.

For the proposed Foundation to be successful, it must be adequately funded and supported. To meet this condition, the Task Force has proposed the establishment of a substantial, government-provided trust fund. In the opinion of the Task Force, use of such a trust fund approach is seen as key to enabling the Foundation to successfully accomplish the diversification goal. I'd like to elaborate on the elements of this trust fund proposal since it so clearly contrasts with other proposals under consideration.

First, I'd like to address the question: "why a trust fund?". The answer relates to the need for stable, long term funding. As suggested by the proposed goal, diversifying American agriculture will take a relatively long time, and the history of erratic and short term funding support for new crop and other new agricultural developments has been a constraint to past success.

In our Task Force deliberations, we considered a variety of funding approaches and relevant operational models and precedents on a worldwide basis. Based on this analysis, we concluded that a trust fund approach would provide the most efficient and effective funding mechanism.

Without a trust fund, excessive diversion of Foundation resources would be needed to merely ensure continuing budget support. This could seriously compromise the efficiency of the organization, since we propose it should be lean and non-bureaucratic, with very tight control over administrative expenses. Dependency upon traditional budgetary processes could also compromise the objectivity and independence needed for the Foundation to be effective.

The second element of the trust fund proposal worth reflection involves our specification that it be provided by government. This may be questioned since the Foundation relates to development and commercialization of products to meet market needs. Over the longer term, we do project that the Foundation would develop supplementary funding from the private sector, and ultimately it should become self-funded through royalties from successful projects it sponsors. However, self-funding for such a Foundation would be well off into the future because of the very long developmental timeframes involved.

In addition, although available data suggest that investments in agricultural research and development do yield attractive rates of return to the overall community, such returns are diffusely spread across many sectors, including farmers/producers, processors and industry, and most importantly to consumers as a group. The net impact of this reality is that conventional private sector rate of return requirements cannot be readily met by agricultural developments undertaken at an early stage.

This diffusion factor combined with the high risks and long timescales involved in the development of new agricultural products, suggests the need for private/public sector risk-sharing. Since the Foundation's mission is clearly in the national interest, initial funding could quite appropriately come from the Federal Government.

Nonetheless, it is important to note that under our proposal the vast majority of the annual expenditures by the Foundation will be invested as "seed" and venture capital in carefully evaluated and selected research and development projects. As conceptualized, such investments would be made only on a cooperative, leveraged basis with both private and other public sector participation. Such a cooperative approach with the private sector should significantly increase the rate of success for developmental projects. It would also serve to multiply the impact of the funds, and reduce the risks to each participant through risk-sharing.

This specification of shared funding forces emphasis on projects with true commercial relevance. It also implies that the funding mechanism for the Foundation permit the freedom to defer expenditures as needed until viable project proposals are available. In other words, there should be no constraint to spend money under a certain deadline. Under the trust fund concept, the money would remain in government coffers until employed, and allocation of investment capital would be made only on the basis of both technical and commercial viability and merit. Over the long term, as revenues are generated from successful projects (or deadline timetables are passed), the trust fund in its entirety would revert back to the Federal Government.

The final consideration warranting comment at this time involves the magnitude of the trust fund. Although we members of the Task Force recognize a proposal for significant governmental expenditure will be controversial in today's era of fiscal stress, we believe we believe we must specify what we think is needed to accomplish the diversification goal. In our view, it would be inadequate and improper for us to leave such a question unanswered, or to imply that a nominal commitment might be sufficient. We are proposing transforming the nation's largest industry, and such a task cannot be accomplished without a substantial commitment of resources.

The magnitude of the task suggests that annual expenditures of at least $75 million may be needed over a period of as much as two decades to adequately diversify American agriculture. This expenditure could therefore amount to as much as $1.5 billion over twenty years. However, attainment of the diversification goal could be expected to return about $30 billion per year (in current dollars) to the farm economy alone, and contribute about $100 billion annually to the nation's economic activity. It could also be expected to generate about 750,000 new jobs. Consequently, the level of investment appears to be justified by the expected economic and job growth returns to the community.

The specified level of annual funding suggests the need for a trust fund totalling about one billion dollars. Again we must keep in mind that this billion dollars is capital that remains in government hands, and under the trust fund proposal only the interest from it will be expended on an allocated basis over a long period of time. Although this certainly is a lot of money, we believe such funds could be derived from reallocation of existing governmental expenditures or redeployment of assets.

Although a variety of approaches might be taken to establish such a trust fund, we have suggested one approach to funding. Specifically, we have suggested that the fund might be established by the sale of $200 million of various commodities held by the Commodity Credit Corporation each year for a five year period. This is one approach that we believe merits consideration, although other approaches may be preferred. However, regardless of the approach taken, we believe the "ramping-up" of the fund over a five year period would be most appropriate for efficient utilization of funds. Such a major effort will require organizational and infrastructural development, and a three to five year period may be needed before full levels of funding can be efficiently employed.

To conclude the matter of the trust fund, we of course envision that mechanisms to ensure adequate control and accountability for public funds would be established and normal standards for such would apply.

To conclude my comments, I must acknowledge that diversification of agriculture is not a new idea. The New Farm and Forest Products Task Force cannot claim to have come up with that original concept. To illustrate the point, we have reviewed the recommendations of the Task Group on New and Special Crops which presented the results of their work to the President's Appointed Bipartisan Commission on Increased Industrial Use of Agricultural Products - in 1957! We have noted that much of what was said 30 years ago is essentially still true today; however, we do hope that will not also be the case again 30 years from now.

We actually don't believe that will happen because we believe diversification of agriculture is an idea for which the time has now come. We perceive the current atmosphere is one of greater awareness and commitment to change than ever before. We also see the new era of biotechnology emerging at a time when a substantial array of new agricultural product opportunities has already been identified. These conditions suggest we are witnessing a convergence of powerful trends and forces for change which provides a real basis for confidence and optimism about the future of American agriculture. Of course, many hard decisions must yet be made, and meaningful action steps must still be initiated. Diversification of agriculture will simply not happen by accident.

We members of the New Farm and Forest Products Task Force do look forward with optimism to the future of our nation's agricultural and forestry industries. We sincerely hope that, in at least some small way, our efforts will have served to catalyze the meaningful actions which will lead to full revitalization of American agriculture, and full realization of the great contributions the industries can make to our nation's strength and prosperity.

Thank you for the opportunity you have provided for us to share our views. I would be pleased to address any questions you may have.

RLS:26JUN87

New Farm and
Forest Products
Task Force

New Farm and Forest Products

Responses to the Challenges And Opportunities Facing American Agriculture

A Report from The New Farm and
Forest Products Task Force to
The Secretary, U.S. Department of
Agriculture, Washington, D.C.

June 25, 1987

United States
Department of
Agriculture

New Farm and
Forest Products
Task Force

Hamilton Building
Room 635
Washington, D.C. 20250-2200

June 25, 1987

Honorable Richard E. Lyng
Secretary of Agriculture
Washington, D. C. 20250

Dear Mr. Secretary:

When the Secretary's Challenge Forum on New Uses for Farm Products was convened in October 1984, it began a dialogue which subsequently led to the formation of the New Farm and Forest Products Task Force. A collaborative effort between industry, academia, and government, our Task Force evolved to address the issues raised at that Forum - issues which we believe are vitally important to the interests of the entire Nation.

Our work over the last two years has convinced us that diversification of agriculture and forestry must become a national priority. Diversification is not only needed to respond to the challenges facing American agriculture, but as a key part of any response to the competitive challenges confronting our entire Nation. As documented in our report, we have found evidence of opportunities for new crops, and other new farm and forest products, to meet real market needs, particularly for industrial uses. Our report therefore proposes specific initiatives to turn such opportunities into realities.

Mr. Secretary, we have recently found our independent results to be remarkably consistent with elements of the President's Competitiveness Initiative launched earlier this year. We also find that 1987 marks notable anniversaries of several significant legislative actions including: the centennial year of the Hatch Act which created the Agricultural Experiment Stations; the 125th anniversary of the founding of your Department; the 25th anniversary of the McIntire-Stennis Act on cooperative forestry research; and, the 10th anniversary of the establishment of an Assistant Secretary for Science and Education. We members of the Task Force hope that our efforts will now serve to catalyze other meaningful actions - ones which will prove to be fitting commemorations to these important precedents.

Respectfully Submitted,

Ronald

Ronald L. Sampson

New Farm and Forest Products
Task Force

Dr. Ronald L. Sampson, Chairman

Contents

Page

Letter of Transmittal i
Table of Contents ii
Executive Summary iii

I. Introduction 1

II. Discussion 4
  Strategic Options
  Process of Innovation
  Opportunities
  Need
  Rewards
  Past Barriers to Success
  Summary of Situation

III. Conclusions 23

IV. Recommendations 24
  National Priority
  National Goal
  Strategies
  Proposals
    Primary:
      Foundation for New Farm and Forest Products 29
    Other:
      Technology Transfer Entity
      Multi-disciplinary Research Centers
      International Programs
      Specific Task Force Efforts
        - Biotechnology
        - Agricultural Information
        - Extension Service
        - Goal Oriented

V. Concluding Comments 45

Appendices
  Task Force Members and Sponsoring Organizations
  Acknowledgements
    - Task Force Associates
    - Task Force Secretariat
  Draft Legislation for
    the Foundation for New Farm and Forest Products

Executive Summary

Agriculture, including forestry, is a strategically vital industry for the United States. Not only is food security critical to national security, but the Nation's domestic economy and balance of trade are both highly dependent upon agriculture. As America's largest industry, agriculture must necessarily be a cornerstone for prosperity and international competitiveness.

With its production capacities already underutilized, U.S. agriculture is facing major challenges which portend a chronic crisis state. The causes of this crisis are complex and related to global developments, in addition to long-term domestic policies. However, regardless of cause, **America now has an overconcentration of agricultural production in a relatively few major food and feed crops, - crops for which worldwide production is increasing, and global import markets are shrinking**.

Although the possibility of a regional calamity causing a temporary shortfall in supply always exists, current trends offer little hope for long-term relief. Indeed, deepening problems can be expected in the future, as an increasing number of exporting countries will be competing for shrinking export markets. **These realities pose sobering challenges to U.S. policymakers**, as well as the agricultural industry itself.

The New Farm and Forest Products Task Force was formed to respond to these challenges. A collaborative effort between industry, academia, and government, the Task Force evolved in mid-1985 from a previous USDA Challenge Forum to address related issues. Upon formation, the Task Force adopted a mission to define and propose meaningful, actionable initiatives based upon a comprehensive analysis of the situation.

Based on its findings, **the Task Force concluded that diversification of agriculture and forestry must become a national priority**. Indeed, the group concluded that diversification, via both new crops and new uses for existing ones, appears to offer the only alternative which promises to enable both: (1) revitalization of ailing segments of the industries; and (2) realization of the full economic potential which agriculture and forestry hold for the Nation.

Continued efforts to increase efficiency and reduce production costs for current commodities continue to be important; however, in the opinion of the Task Force, at least equal emphasis should be placed on diversification into new crops and other new products. Importantly, the group did find evidence that **significant opportunities exist for new farm and forest products to meet real market needs - particularly in industrial, non-food application areas**.

Based on its findings and conclusions, the New Farm and Forest Products Task Force proposes adoption of the following **national goal**:

To develop and commercialize within 25 years, an array of new farm and forest products, utilizing at least 150 million acres of productive capacity, to meet market needs representing net new demand for agricultural and forestry production.

Such a goal represents the equivalent development of two to three new soybean crops - in about one-half the time the soybean required to rise to its current level of significance. The Task Force estimates that attainment of such a goal today would: generate about 750,000 new jobs; increase farm income by about $30 billion per year; and annually contribute about $100 billion in activity to the Nation's economy.

The Task Force believes the proposed goal is appropriate and attainable. However, success in achieving it will require both technological and institutional innovation. Specifically, **success in large scale diversification of American agriculture will depend upon: (1) adoption of appropriate strategies; and (2) implementation of those strategies through initiatives which provide innovative organizational approaches to overcome past limitations and barriers to success**. Although the quality of public agricultural research has always been quite high, concentration upon production of current commodities, and the lack of mechanisms to ensure commercial relevance and effective technology transfer to industry, have been limitations in the past.

The **diversification strategies** recommended by the Task Force are as follows:

1. Increase national emphasis on, and reallocate existing resources to the development of new farm and forest products;

2. Establish a consensus that diversification of agriculture and forestry should be a national priority, based upon an understanding, across a broad spectrum of society, of the vital contributions that agriculture and forestry make to the health and wealth of the Nation;

3. Establish mechanisms to increase private/public sector collaboration and cooperation in the development of new farm and forest products;

4. Establish mechanisms to facilitate agricultural technology transfer, particularly between the public research and private industrial sectors;

5. Ensure that responsible biotechnological developments can proceed at a rate which retains national leadership in agricultural applications; and

6. Establish an organized program to identify opportunities for encouraging, and reducing barriers to, the development of new farm and forest products.

To implement the strategies and thereby enable attainment of the diversification goal, the New Farm and Forest Products Task Force proposes several specific action steps and initiatives. Each proposal addresses a particular need, and is intended to build upon existing, relevant programs and organizations in both the private and public sectors. However, one of the proposals is considered to be of paramount importance. Specifically, the Task Force considers **the establishment of an independent organizational entity, dedicated to achievement of the diversification goal and provided with adequate resources to attain it, is essential for success.**

In its report, **the Task Force proposes the establishment of the Foundation for New Farm and Forest Products.** The proposed organization would be an autonomous, non-profit corporate entity with a mission to foster and facilitate the development and commercialization of new farm and forest products. As conceptualized, the Foundation would be specifically charged with the responsibility to achieve the diversification goal. Bridging both private and public sectors, **the Foundation would serve as an advocate, catalyst, coordinator, and cooperative funding source for the development of new farm and forest products.**

The Foundation proposal builds upon the results of prior studies and proven organizational models. **A key element of the proposal involves establishment of a trust fund to provide a stable, long-term funding source for the needed cooperative private/public sector research programs.** Based on models in other areas of industry and technology, the minimum requirement for such a trust fund would involve a one-time allocation of $100 million - perhaps generated by a single diversion from current commodity support programs. However, although such a minimal program would represent a step in the right direction, it would be inadequate to undertake the enormous and vitally important task of diversifying American agriculture.

To accomplish the diversification goal, **the Task Force recommends that the Foundation be initially funded by proceeds from a $1 billion trust fund invested solely in U.S. Treasury securities.** It is proposed that the fund be established by the sale of $200 million of various commodities held by the Commodity Credit Corporation each year for a five year period. When fully established, income from the trust would annually provide over $75 million as a significant, sustained source of long term "seed and venture capital". Importantly, investments would be directed toward carefully selected, cooperative projects in which private companies and other public organizations are also willing to invest. Such an approach would leverage funding, help ensure market focus, and also enhance cooperation and technology transfer between the public and private sectors. **Foundation investments would be made with provisions to secure royalty returns from successful projects, and the trust fund would ultimately revert back to the Federal Government.**

As detailed in its report, the Task Force proposes several other initiatives related to: (a) commercialization mechanisms for USDA research; (b) multi-disciplinary university research centers relevant to new farm and forest product technologies; (c) international cooperation to develop agricultural sources for industrial raw materials, on a selective basis as mandated by the Critical Agricultural Materials Act of 1984, PL 98284; and (d) task force efforts to address other specific needs.

The New Farm and Forest Products Task Force views its recommendations and proposals as merely starting points - actions to begin the concerted, long-term effort needed to revitalize U.S. agriculture and forestry, and ensure they remain as cornerstones of American competitiveness and prosperity.

I. INTRODUCTION

The Challenge. . .

The New Farm and Forest Products Task Force evolved as a response to the challenges faced by U.S. agriculture and forestry!

Secretary of Agriculture John Block convened a Challenge Forum in October, 1984, to begin a private/public sector dialogue on the development of new crops and new uses for existing crops, including those from forestry. In opening the Forum, Secretary Block said:

> "I've called you here to issue a challenge. I want to impress upon you a sharp sense of the importance, the potential, and the urgency of the exploration of new directions for agricultural products and markets. . . .As an industry, agriculture can't make solid progress until it has decided which way it wants to walk", he said. "We are rethinking our destination and rethinking the paths we plan to take to get there. Certainly there are some new routes we need to explore."

Many in the audience took up the challenge, and after subsequent dialogue the New Farm and Forest Products Task Force was formed to continue to address the issues raised at that Forum. Because these issues focused on new crops and new uses for existing crops, they seemingly addressed only narrow aspects of the problems and challenges faced by U. S. agriculture and forestry. However, as the dialogue developed, one point became increasingly obvious to the participants. The relative lack of production and end-use alternatives for U.S. agricultural and forestry products could be seen as a pervasive factor underlying the current crisis situation. Although an admittedly simplistic view, the problems facing U.S. agriculture could be seen as resulting in large measure from an overconcentration of production in a relatively few major food and feed crops.

The Organization. . .

A collaborative effort between the private and public sectors, the Task Force drew about one-half of its membership from industry and other private sector organizations, and about one-quarter each from government and academia. A Secretariat was formed within the Department of Agriculture to provide liaison with the Task Force, while direct coordination and support was provided via the USDA's Office of Critical Materials. The Task Force held its formative meeting in Washington in June, 1985, with subsequent meetings hosted by the Procter & Gamble Company and the Monsanto Company, as well as the USDA. Although each individual had an organizational sponsor, the group operated independently on a self-sustaining basis without outside budgetary support.

The Approach. . .

The Task Force intended to build upon what was already known and what had already been done. The group recognized that a high level of awareness of, and concern for the problems facing U.S. agriculture already existed. This had resulted in relevant programs being established within both the private and public sectors during the last few years. Accordingly, the Task Force focused on identifying unmet needs and gaps which still existed and could be addressed by new initiatives.

The group's efforts drew upon the wealth of existing knowledge and expertise available throughout the Nation and overseas. Deliberations included: reviews of prior literature and reports; dialogue with other interested organizations and individuals; and, testimony from expert witnesses drawn from the private and public sectors. (These witnesses and other non-member contributors to the work of the Task Force are acknowledged elsewhere as "Task Force Associates".)

In its investigations and deliberations, the Task Force was confronted by a rather overwhelming body of information and ideas. Consequently, the group's initial role was largely one of: (a) analyzing and distilling vast amounts of information into a few key findings and recommendations; and then (b) translating those findings and recommendations into actionable and meaningful proposals. The intention was to complement and enhance the relevant programs already in place throughout the private and public sectors.

The Task . . .

During its initial deliberations, the group became convinced of the need and opportunity to diversify U.S. agriculture and foresty. Consequently, the Task Force adopted the following Mission Statement:

> "The New Farm and Forest Products (NFFP) Task Force will devise and propose to the Secretary of Agriculture a plan of action for the implementation of positive steps and initiatives to develop new products from the Nation's farms and forests to be used by the agricultural and industrial communities to meet the needs of the country."

In general terms, the mission was to catalyze action which would lead to more complete utilization of the productive capacity of American agriculture to meet an array of strategic, industrial, economic, and social needs.

Appropriate objectives, strategies, and plans were then adopted to carry out its self-selected mission. To more effectively concentrate its efforts, the group excluded initial considerations of animal-derived products. Attention was therefore focused on the development of new plant-derived farm and forestry products - encompassing both new crops and new uses for existing crops.

To accomplish its mission, the Task Force concentrated on the definition of meaningful, actionable proposals. The group intended to propose a relatively few steps and initiatives which not only warranted priority attention, but also were judged to be actionable. To be actionable, the proposals needed to be specific, and also of a character which could be supported by a broad consensus of differing interest groups—many of whom were represented on the Task Force itself.

The Task Force recognized that diversification of agriculture was not a new idea. Indeed, development of new crops and other new agriculturally-based products had been the subject of many studies and proposals, particularly during the last few decades. However, in spite of such past recognition and attention, relatively little progress had been made to accomplish diversification on the large scale needed to ensure full vitality and productivity for American agriculture and forestry.

Confirmation was therefore needed to support the premise that opportunities exist for new agricultural and forestry products. Focus was maintained on opportunities to meet major, real market needs, so such developments truly would be market-driven and justified. In addition, determination of what is needed to achieve success in the future would necessarily require an understanding of what limited large scale diversification was in the past.

II. DISCUSSION

The New Farm and Forest Products Task Force derived its conclusions and recommendations through analysis of the following considerations:

A. Strategic options facing agriculture;

B. Process of innovation as applied to agriculture;

C. Opportunities for diversification;

D. Needs for diversification;

E. Rewards for action and penalties for inaction; and

F. Past barriers to success.

The discussion below summarizes the group's findings and analysis.

A. Strategic Options

The situation facing the U.S. agricultural industry is really no different from that facing any other industry. Regardless of category, an industry must either innovate or perish. Either new products must be developed to replace those which are obsolete or mature and declining, or the related industry will simply cease to exist. Although this reality has been more obvious for other American industries, it also applies to American agriculture.

Option 1: Abandon Agriculture

The Nation could choose to withdraw support from, and effectively abandon agriculture as an industry. Emphasis could then be placed on the development of some other industry with more (apparent) promise. However, even if the strategic and social consequences of such action could be managed, it is unlikely that any industry or segment of the economy could match, let alone exceed, the current and potential value of agriculture to the economy. Indeed, given the critical importance of agriculture to the Nation, this option is simply not an option!

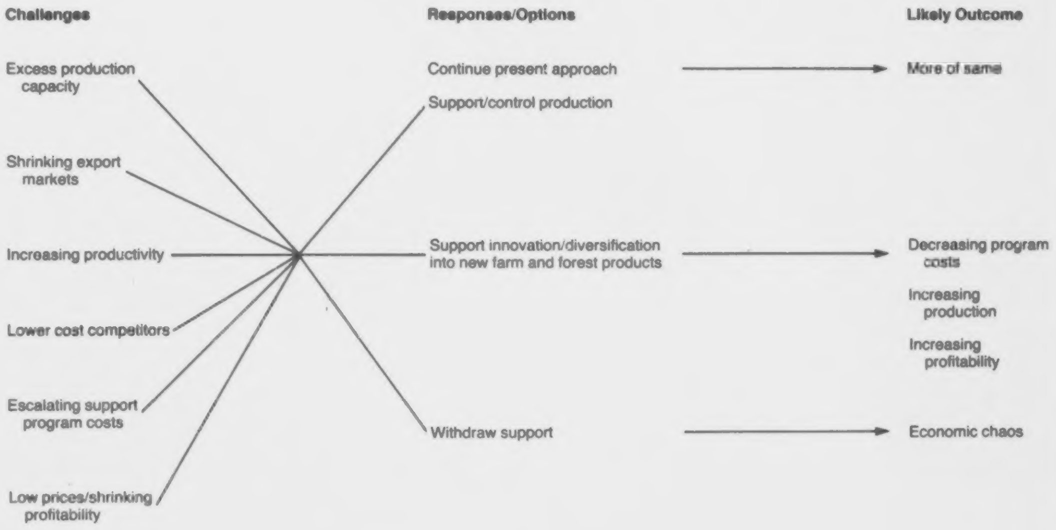
Option 2: Continue Present Course with Present Products

The Nation could continue along the present path of concentrated and somewhat controlled production of current major crops and products. Policy-makers could decide that the current support system via transfer payments should be continued indefinitely, and expanded as required. Under these circumstances, agriculture becomes merely another part of our serious national economic problems, and not part of the cure for them.

Option 3: Innovate with New Products

However, the Nation could also choose to facilitate innovation in agriculture, that is the development and commercialization of new products from American farms and forests. Just as innovation and new products provide the only viable alternative to the demise of other industries, they also provide the only truly viable option for agriculture. For perspective on what this means to agriculture, some consideration of the basic innovation process is worthwhile.

Strategic Options for Agriculture


Challenges
Excess production capacity
Shrinking export markets
Increasing productivity
Lower cost competitors
Escalating support program costs
Low prices/shrinking profitability
Responses/Options
Continue present approach
Support/control production
Support innovation/diversification into new farm and forest products
Withdraw support
Likely Outcome
More of same
Decreasing program costs
Increasing production
Increasing profitability
Economic chaos

B. The Process of Innovation

A useful dictionary definition of innovation worth reflection is "the process of creating change by introducing something new". Innovation therefore means change and new approaches. Regardless of the industrial category, the process of innovation is a very complex and iterative one. However, it can be useful to think of it as a simple linear process of three steps: (1) Discovery; (2) Translation; and (3) Commercialization.

1. Discovery

In the Discovery stage, a basic idea is conceptualized and developed to the point wherein it can be demonstrated in a relatively simple form. Technological discovery usually results from an organized program of research and exploration, and may yield inventions. In this stage, technical feasibility and market potential are assessed on a very preliminary, and largely judgmental, basis. However, particular attention is paid to identifying what market need the concept plausibly addresses. Financing of innovation at this stage is most difficult, and requires use of "seed capital". This term refers to investments which are made on the basis of judgment or principle because a meaningful analysis of risks and financial returns is not possible.

2. Translation

Concepts, which appear to have sufficient merit, progress to the second phase - Translation. The basic concept is translated into a viable product form and tested. Technical development is married with marketability. The product, and the process to make it, are progressed to the point that commercial viability can be meaningfully assessed. This may include limited commercialization or test marketing. Technical feasibility, market response, costs and potential financial returns are all evaluated to support a decision on whether or not to proceed to market. Innovations in this stage of development require the equivalent of venture capital. Such investments are undertaken at higher levels of risk than traditional financing permits, but based on meaningful analyses of risks and potential rewards.

3. Commercialization

A favorable outcome of the second step of the process leads to Commercialization. The developed and tested product is taken to market, and confirmation of all the prior estimates and projections is made. This is the moment of truth—when the market casts the only meaningful vote. Success is rewarded with financial rewards and business prosperity. However, failure in this stage is costly. Continued survival of a business or an industry depends on the returns from the successes being sufficient to pay back the costs of all the failures as well. Once a venture becomes an established commercial one, traditional financing sources can be utilized.

4. Other Considerations

On the Process. . .
Importantly, the innovation process is **necessarily multi-disciplinary** at each stage because market and technical considerations must be jointly addressed from the

beginning. Nonetheless, each stage requires somewhat differing types and forms of resources. As indicated above, this is particularly true in terms of financing. Uncertainties (i.e., unknown or unquantifiable risks) are the highest in the Discovery stage. As an innovation progresses, uncertainties are transformed into assessable risks, which in turn are translated into known experience. Any development at the initial stage faces extremely **long odds against success and long development timetables** until returns are available from the few successes. Global data reveals that commercial success rates for concepts in the Discovery stage typically range from one to five per cent. In addition, the average time from conceptualization (when investment begins) to commercialization (when financial returns begin) is about seven years.

In agriculture, there are no comparable data available to meaningfully assess the success rates from early stage discoveries. However, comparable rates to those reported in other industries could be expected. Importantly, historical experience suggests **that the timescale for innovation in agriculture is much longer than that of other industries**—with a minimum of ten to twenty years required for new crop developments or major modifications. Although advances in biological technologies promise to accelerate future agricultural developments, they are unlikely to ever accelerate them faster than typical development timetables in other industries.

On Product Reasons-for-Being. . .
It is prudent to seek superior performance, and not cost-savings, as the principle driving force for major new product developments. In this context, superior performance means inherently superior value in the customer's view. In industrial products, it can be objectively measured; however, in consumer products, such as food, subjective preference determines performance value. Of course, the combination of superior performance and lower costs provides the best platform for market success.

Experience indicates that major developmental projects, which require changes in customer habits or product usage, are less likely to succeed commercially when they are predicated solely upon lower costs as a reason-for-being. Experience suggests that in-use cost-reductions, delivered via new products, are far more frequently projected, than actually realized. As a general rule, the projected costs of new products tend to be underestimated. In addition, free-market prices for established, competitive products are moving targets - ones which do not necessarily follow trend-line projections. (In this regard, it should be noted that sugar replacement by corn sweeteners cannot be considered a true exception, since the domestic price of sugar has been controlled and not subjected to normal free-market fluctuations.)

5. The Importance of Innovation

With such low odds for success and long timetables for payouts, why would any industry attempt innovation, that is, new product development? The simple answer is that already suggested—there is no alternative!

Technological Innovation. . .
Mr. Peter Drucker and others have pointed out that technological innovation is key to economic growth and the development of entrepreneurial economies, which avoid the economic stagnations which otherwise result from the decline of mature industries. Although that message was delivered in a general industrial context, it appears to apply quite directly to agriculture—particularly if one views current major agricultural commodities as mature industries face decline.

Institutional Innovation. . .
Professor Vernon Ruttan of the University of Minnesota has pointed out the particular importance of institutional innovation in agricultural developments when he wrote:

> ". . .institutional innovations can be designed both to generate technical change in a manner consistent with resource endowments and product demand and to bias the incidence of benefits and burdens in a manner consistent with social policy. Institutional innovation is both a more powerful and a more reliable instrument of reform than technical change. . . .The evidence suggests that the institutional linkages that have provided effective articulation between science, technology, and agriculture have continued to be productive sources of economic growth in both developed and developing countries. There is much that can be learned from this experience by those who are not blinded by outmoded status symbols or cultural constraints."

Such considerations suggest that **effective responses to the challenges facing American agriculture must necessarily involve both technological and institutional innovation**. However, major steps to foster and facilitate new product innovation in agriculture must be predicated on the existence of real and substantial commercial opportunities.

C. The Opportunities for Diversification

The plant kingdom represents a huge repository of diverse materials and substances which have developed through millions of years of evolution. Fewer than one percent of the species of seed-bearing plants have been utilized commercially, and fewer than three percent have been evaluated commercially. These facts alone suggest that many commercial opportunities still remain hidden in the plant kingdom. However, any experienced developer of products approaches such propositions with skepticism since opportunities are real only if useful products can be cost-effectively found and developed to meet identifiable market needs.

The task of screening and classifying plant materials and matching their potential products with market needs is an awesome one. Such an undertaking requires a carefully planned and administered research program which is focused on market needs and conducted on a multi-disciplinary basis cooperatively between both the private and public sectors. Historically, this combination of conditions has seldom been met.

In its investigations, the Task Force was particularly focused on identifying opportunities in usage categories which would not significantly compete with, or displace, current U.S. farm or forest products. Such opportunities are of particular interest because they represent potential new market demand for domestic production.

Determination of developmental priorities for specific project opportunities was beyond the scope of the Task Force's program. Nonetheless, the Task Force did find ample evidence for the existence of many, substantial opportunities for new farm and forest products to meet existing and indicated market needs—particularly for industrial raw materials.

The National Agricultural Library in Washington D. C. has established Information Centers in several key subject areas, including Critical Agricultural Materials. Substantial bibliographies on particular new crop candidates can be obtained through the Centers.

1. Industrial Raw Materials

As pointed out in a 1984 Critical Materials Task Force Report on "The Role of American Agriculture and Forestry in Maintaining Supplies of Critical Materials":

> "The United States depends on other nations for a broad range of materials and manufactured products important to U.S. industry. Among these are agriculturally produced plant substances and mined materials, including petroleum. Many of these products are or could be agriculturally produced in the United States and used as industrial materials or as renewable replacements for petroleum as a source of feedstock in the chemicals industry. Three of the industrial materials are classified by law as 'strategic,' meaning critical to our national defense. These are natural rubber, castor oil, and sperm whale oil."

As such reports suggest, identifiable market needs (and technical leads to meet them from domestic agricultural sources) do exist; however, the challenges to develop them into economically and commercially viable opportunities are substantial. The examples cited below illustrate such industrial market opportunities for products from both new crops and existing crops. These include:

1. Pulp and fiber products from trees and Kenaf for newsprint, paper, composite structural materials and other products;

2. Rubber, resins and waxes from Guayule for use in tires, tackifiers, coatings, etc.;

3. Industrial oils from the Chinese Tallow Tree, Crambe, Cuphea, Jojoba, Meadowfoam, Rapeseed, and Soybean for use in lubricants, cosmetics, soaps and detergents, plastics, coatings, etc.;

4. Alcohol from Corn, other starchy crops and biomass for use as fuel additives (particularly in applications, such as aviation fuel, where indicated performance advantages exist);

5. Absorbents (for moisture removal and chemical separations) and other chemicals from Corn and other starchy crops; and

6. Carbon char and chemicals from the pyrolysis of hardwoods and woody biomass needed to make high-grade metallurgical products and an array of organic chemicals.

2. High Value Specialty Products

In addition to the industrial product illustrations above, there also appear to be significant opportunities to develop:

(1) high-value, biologically active products (from both land- and marine-based plant cultivation) for use in pharmaceuticals, insecticides, herbicides and disease control agents for both plants and animals;

(2) ornamental horticultural products; and

(3) relatively high value specialty food products from both new horticultural crops and aquaculture.

Long term opportunities for pharmaceuticals to be obtained from plant sources appear significant. They are illustrated by extractives from existing plants, such as the Madagascar periwinkle. They also include potential products derived from genetically modified existing crops. Such prospects are suggested by reports that production of a human hormone (characteristic in pregnancy) has been induced in the petunia. Natural insecticides, such as those reported from the Neem tree, offer other exciting possibilities for effective and environmentally-preferred applications to protect livestock. In horticultural categories, Impatiens demonstrates the opportunities available from germplasm collections overseas. Impatiens is a relatively new ornamental plant product which now generates sales second only to petunia.

Within the last few years, imports of specialty food products have risen dramatically in response to consumer emphasis on nutrition and increased food variety. Nutritional and variety concerns are now quite powerful motivations for consumer purchases, and established consumption trends have created new demands, and therefore opportunities, for new food products. Increasingly being met by imports, the domestic market demand for high value specialty food products now annually amounts to billions of dollars. Many related imports are in categories which hold potential for development of U.S. production sources. Development of the U.S. kiwifruit industry (generating well over $25 million in annual sales) illustrates how U.S. agriculture can respond to such market opportunities which are first recognized and realized by importers.

Although the value of each specific specialty product might be relatively small when compared with total U.S. agriculture, the cumulative effect (particularly on net profitability) can be quite substantial. It is noteworthy that development of smaller volume, specialty products is a trend which characterizes most industries—particularly those related to consumer products. Indeed, in manufacturing industries, there is markedly increased emphasis on development of flexible manufacturing systems, which can deliver high quality products for niche markets at competitive costs.

Some of the changes in market demand may be explained by an increasingly segmented population with specific desires and needs. In particular, populations which are more diverse ethnically have greater interest in niche products, particularly in food categories. Such changes in demand patterns can particularly create opportunities for relatively small farms.

3. New Uses for Existing Crops

The Task Force found some current programs, to develop new uses for existing crops, to be particularly encouraging. These were the ones which were primarily focused on delivering superior product performance, and not cost reductions, as the reason for being. An example is found in the effort being mounted, under the sponsorship of the National Corn Growers Association, to develop ethanol as an aviation fuel additive. This project is based on indications that use of alcohol, as an additive, can prevent significant fuel system problems related to moisture and microbial growth in the fuel.

4. Existing Developmental Programs

Additional encouragement was found in the existence of several modest, but promising, cooperative private/public sector projects to develop and commercialize new crops. Some of these projects are related to established programs, such as the ones coordinated by the USDA's Office of Critical Materials. These include the Kenaf (for newsprint) and Guayule (for natural rubber) demonstration projects. Others are based on private sector initiatives, such as the Cuphea research project at Oregon State University. Jointly funded and supported by industry, government and academia, this latter project represents an exploratory effort to develop a new crop source for certain industrial oils.

Although symbolic of the opportunities available to diversify agriculture, such existing programs are relatively small in scope. Consequently, although encouraging they represent only modest, and quite insufficient, steps toward diversification of agriculture on the scale required. Nonetheless, the existence of these programs does support the premise that identifiable opportunities in fact do exist for new farm and forest products to meet real market needs.

5. The Promise of Biotechnology

Biotechnology, particularly in combination with the newly emerging information and robotics technologies, promises to enable the development of new agricultural products which otherwise would not have been possible. Indeed, genetic manipulation, such as recombinant-DNA techniques, enables the transfer of desired properties from potential new crops, or even wild plants in nature, to existing crops. This approach promises the delivery of new agricultural products far more quickly and cost effectively than ever before possible.

Obviously, such prospects suggest a major, new era may be in the offing—one of accelerated plant breeding via biotechnology.

Of course, biotechnological developments present challenges, as well as opportunities. Biotechnological developments promise to increase crop yields per acre and reduce the number of acres needed to produce a given amount of product. This will create additional surplus acreage, and in turn, increase the need for new crop alternatives. Since such changes due to applications of new technologies throughout the world are inescapable, the challenge for America is to lead, and not follow, in such realizations.

Animal-product applications, from biotechnological developments, are generally in a more advanced stage of development than plant-product ones. Indeed, at the present time, biotechnology is not expected to deliver a large scale commercial impact in plant-derived product areas before the end of the century. However, over the longer term, there appear to be greater, and virtually boundless, opportunities for new plant-derived farm and forest products via biotechnology. Most projections on the size of worldwide markets for biotechnologically-derived products indicate the vast majority will be found in agriculture and food products. Estimates suggest such markets will exceed $100 billion per year in value by the turn of the century. There now seems to be no question as to whether or not biotechnology will have a monumental impact on agriculture. The only questions seem to be: (1) when it will happen; and (2) who will lead in international applications, and thereby reap the most benefits?

With regard to the former question, it is noteworthy that biotechnology appears to be an exception to the general rule that developments take longer than initially predicted. Indeed, the rate of progress in biotechnology appears to be accelerating and, remarkably, it appears that major milestones are frequently passed earlier than predicted. This is in part due to the extraordinary marriage of information technology with biotechnology which appears to be generating much synergism.

With regard to the latter question, it appears that **those countries which can most successfully manage the technology transfer of relevant research results into commercial applications will realize the greatest returns.** It also appears that the rate of commercialization progress in biotechnology will largely be determined by public opinion and support in each country. **Those nations which best manage public uncertainties will likely lead the world in the commercial applications of biotechnology.** In this regard, certain other countries, most notably Japan, have significant advantages over the United States.

D. The Need for Diversification

In the opinion of the Task Force, diversification of American agriculture is of vital importance to the Nation because of the following considerations:

1. The strategic importance of agriculture and forestry to the Nation's economy;

2. The character of the agricultural industry; and

3. The challenges posed to agriculture by global changes and competition.

1. The Importance of Agriculture

Agriculture is a strategically vital American industry! As stated in a recent report by the Office of Technology Assessment:

> "Despite numerous theories about 'post industrial' societies, agriculture remains a crucial part of the U.S. economy."

Indeed, U.S. agriculture is the Nation's largest and most important production industry. As Dr. Dale Wolf of the DuPont Company recently wrote,

> "The American food and agriculture system stands atop the ranks of global enterprise. It is the world's largest commercial industry with assets exceeding $1 trillion. It accounts for 20 percent of the United States' gross national product. And more than 23 million Americans are employed in agriculture-related jobs--most of which are beyond the farm gate."

These facts alone place agriculture well above the combination of steel and automobile industries in employment and overall economic impact.

Agriculture is a significant generator of domestic jobs! Agricultural sectors generate over 25 jobs per $1 million of output—slightly above that of the automobile industry. Although only a small fraction of these jobs actually are on the farm, the labor productivity of agriculture and related businesses has been growing at a faster rate than that of other sectors of the economy. Forest product industries alone provide jobs to about 1.4 million employees and yield manufactured goods valued at over $45 billion dollars per year.

American agriculture is an important generator of foreign exchange! For over a decade, agriculture has been a consistently significant contributor to the Nation's balance of trade, and generated positive surpluses which offset losses in other industries. In addition, according to the Office of Technology Assessment (OTA) about one half of the dollars gained or lost in agricultural trade occur in businesses outside traditional farming sectors.

Agriculture provides strategic food security for the Nation, and forestry provides massive amounts of raw materials for industry! In particular, timber from American forests comprises about a quarter of all the industrial raw materials consumed in this country. Of course, forests are also used to provide a source of heat to millions of homes.

2. The Character of Agriculture

The OTA recently observed that, as one of the Nation's most capital- and research-intensive industries, agriculture is truly a **"high-technology" enterprise.**

In the words of Dr. Howard Schneiderman of the Monsanto Company,

> "Agriculture has made the transition from a resource-based industry to a science-based one. . .technological innovations are crucial to enable the

> American farmer to compete in the world's agricultural market place for both U.S. and world-wide markets, and are crucial to enable the nation to realize the economic potential of plants and livestock as annually renewable sources of wealth."

Indeed, the strengths of U.S. agriculture are largely viewed as based: on a strong commitment to the role of science; and, the entrepreneurial spirit of the Nation, which fosters transfer of new technology to the marketplace. The many new and emerging technologies, particularly biotechnology, promise to enable U.S. agriculture to remain a cornerstone for economic prosperity and international competitiveness.

Of course, **agriculture has always been a "bio-tech"** industry! Fundamentally, agriculture is an industry based on biology, and much of the progress achieved in agriculture has been through the genetic manipulation of plants and animals, that is, via breeding processes including forced and random mutations. By providing the technological means to accelerate the process, and actually improve its precision, modern biotechnology (particularly including genetic engineering) appears to offer the means to achieve dramatic future progress in agricultural innovation.

3. The Challenges Faced by Agriculture

American agriculture faces enormous challenges including: (a) excess capacity; (b) a loss of competitiveness; (c) shrinking export markets; and (d) a global trend toward higher valued products.

a. Excess Capacity

The productive capacity of U.S. agriculture is greatly under-utilized. The country today has carryover stocks of between six months and one year's production of major commodities, with productivity continuing to increase at a faster rate than demand. **Estimates of land in excess of production needs to meet both domestic and export market demand range as high as 150 million acres—with about one third of that readily available from the Conservation Reserve Program**. This represents an enormously wasted national asset which, if transformed into a more productive one through new products, would have a profoundly positive impact on the Nation's economy.

b. Loss of Competitiveness

In addition, the ability of the U.S. to compete for the shrinking export markets is handicapped by the fact that on a National average cost basis, **the U.S. is no longer the low cost producer for its major crops!** According to the Office of Technology Assessment, technical advances in other countries now allow foreign producers to grow many important crops below average U.S. costs. U.S. production costs are of course highly variable across regions of the country and producers of different scales. Consequently, while a large percentage of U.S. farms are competitive with the most efficient producing areas of the world, many U.S. farmers are operating at costs which are well above world prices.

c. Shrinking Export Markets

Foreign trade is vital to agriculture, yet agricultural exports are declining! Despite its relative strengths within the Nation's economy, agriculture is highly dependent upon global markets (just as the Nation is highly dependent upon the export earnings of agriculture). In all but eight of the last 64 years, U.S. agricultural production has exceeded domestic demand, and about one-third of production is currently destined for overseas sales.

Nonetheless, U.S. export markets have been shrinking over the last several years, and the agricultural trade surplus for 1986 appears to have been the lowest since 1973. With declining markets, profit margins for producers have narrowed (and even disappeared for some) in spite of the soaring costs of subsidy and price support programs reaching over $25 billion in 1986 alone.

The causes of the losses in foreign trade are complex and related to many global developments, as well as long-term domestic policies! There is considerable evidence that exports of major U.S. commodities may be facing a continued, long-term decline, and not merely experiencing a self-correcting, temporary downturn. As reported by the Office of Technology Assessment, world exports, as a share of world production, are declining for the key commodities of wheat, corn and soybeans. This appears to largely be the result of fundamental shifts in the global balance of production and consumption. Consequently, **continued shrinkage of export markets for U.S. farm products appears likely—regardless of continued productivity or cost-reduction gains**.

There is evidence that the global quantity of major commodities available for export sales are likely to continue to increase at a rate exceeding import demand for an indefinite period. In other words, global production capacity appears likely to continue to increase faster than consumption demand. This trend is due largely to a worldwide movement toward national self-sufficiency in major food crops—even when the cost of domestic production is higher than imports from lower cost producers. This trend is unlikely to change over the foreseeable future since food security is rather universally considered a paramount national need. In addition, experience has shown that trade negotiations to open, or reopen, inaccessible or restricted food markets face great difficulties.

The 1980 predictions of greatly increased future demand for food commodities from the U.S. and other developed countries have simply not proven to be true. Indeed in the words of Mr. Dennis Avery of the U.S. Department of State,

> "The bad news for the American farmer is that the global bad news (of 1980) is wrong. The world is not on the brink of famine or ecological disaster brought on by desperate food needs."

The world now has in place an enormous and steadily increasing capacity to produce basic agricultural commodities in quantities which well exceed demand. Since the early 1970s, global production of feedgrains and oil crops has been increasing at a rate faster than both population and demand. Indeed, the World Bank has recently concluded that the problems of food shortages in the world are not due to a lack of available supply or high prices, but rather a lack of purchasing power of some households and nations. That report concludes that **world hunger is not an issue of supply or price, but of poverty and the need for economic growth.**

Net world import markets for basic grains are shrinking! A "green revolution", triggered by a network of international agricultural research centers, is transforming the agriculture of developing countries and making them increasingly self-sufficient. Farm output in less-developed countries rose by 33 percent in the decade from 1972 to 1982, while that of the developed countries rose only 18 percent. Importantly, the European Common Market also changed from a net importer to net exporter during that period, and became a primary competitor in the world marketplace. Overall, between 1982 and 1985, world production of grain increased by more than 100 million tons annually—with none of the increase coming from the traditional grain exporting countries.

The major effects of increased production in the developing countries was to reduce net import demand, rather than contribute to the world export supply. Nonetheless, the list of the world's net grain exporters in 1984 included countries such as Burma, Chile, Finland, Hungary, India, and Zimbabwe. Additionally, countries such as Sweden, Norway, Saudi Arabia, China, and Indonesia are now counted among the countries with farm surpluses. In 1985, Bangladesh was nearly self-sufficient in rice production and rapidly becoming a significant producer of wheat as well.

The increases in global production cited above have principally resulted from the introduction of new technologies. These technologies include higher yielding, drought and disease resistant, plant varieties. Changes in governmental policies also have contributed to production gains. These are illustrated by China's movement toward "free enterprise farming" and the European Common Market's agricultural production strategies. In addition, the world seems to be on the threshold of a major new era of advances in agricultural productivity. Indeed, as suggested above, the new era of biotechnology promises to deliver even greater increases in productivity than achieved during the previous mechanical and chemical eras.

d. Trends Toward High Value Products

In contrast to the situation for major commodities, international trade in high value agricultural products (HVPs) is increasing! The OTA reports that world trade in HVPs, such as processed commodities and horticultural crops, now exceeds world trade in bulk agricultural commodities. Furthermore, the market value of trade in HVPs is projected to continue to grow significantly during the next few years. Other countries are focusing efforts in such product areas and, as a result, are exceeding U.S. performance in them. In fact, the U.S. now has a negative balance of trade in HVP areas.

As an overview, the realities discussed above suggest a strong need for diversification of agriculture. In the least, they pose sobering challenges to U.S. policymakers. **Although continued efforts to increase efficiency and reduce produc-**

tion costs for current commodities are certainly justified, such efforts alone appear quite insufficient to address the challenges faced by American agriculture. Indeed, such continued production over-emphasis appears likely to lead to continued reductions in output, and preclude full realization of the great economic potential that U.S. agriculture offers the Nation.

E. The Rewards for Diversification

The potential rewards to the Nation for action to diversify agriculture, and the prospective penalties for inaction, appear substantial. The rewards are found in terms of: economic returns, as illustrated by the soybean; revitalization of ailing sectors of agriculture; increased international competitiveness; and a strengthened national economy.

1. Economic Returns

In general, the economic returns to the community for agricultural research are quite high. For example, it has been reported that in the United States **annual rates of return to the public on expenditures for agricultural research are of the order of 50 percent**. Although such rates of return are highly attractive in community terms, they are of course dispersed across the various sectors of producers, processors, and consumers.

Indicated returns from new crop development expenditures are even more substantial. A socio-economic analysis of the costs and benefits of a 14-year investment made by Canada in rapeseed (Canola) crop development estimated an annual net economic return to their society at slightly over 100 percent.

Despite the fact that the rates of return for investments in new crop developments appear to exceed those of yield increases for existing crops, historical research and development expenditures have been overwhelmingly concentrated in the latter areas. This inbalance is readily understandable since large constituencies exist for current crops, while the constituencies for future crops exist only in the future.

The soybean illustrates both the difficulties and the rewards associated with developing new crops. Investments in soybean research during the early 1900s reportedly met stiff resistance, and it was not until the latter half of the century that the soybean began to realize its potential. Nonetheless, it has been estimated that over the period 1925 to 1985, soybeans contributed over $500 billion to the nation's economy.

Development of the soybean also contributed to other major changes in the agricultural industry, and in consumer diets. The soybean made available an economical source of high quality protein meal for animal and poultry feed. This in turn led to a dramatic expansion in the production of red meat and poultry products which then, in turn, further expanded the farm economy. In addition, the availability of a economical source of high grade vegetable oil enabled American agriculture to address increasing consumer demands for unsaturated fat and oil products, such as margarine. These needs might otherwise have been met by imported products.

As demonstrated by the soybean example, the potential economic gain to the Nation from the transformation of 150 million acres into a more productive use would be enormous. A relatively new crop to America, the soybean essentially provided an alternative to corn, wheat, and cotton. From 1930 to 1980, soybean-plantings increased from insignificance to over 60 million acres. With soybeans generating an annual production value in the range of $10 to 12 billion, the loss to the U.S. economy would have been immense had that alternative not been developed. (Not only would the indicated income have been lost, but additional excess supplies of the commodities it replaced would likely have resulted.)

Extrapolation of the soybean model to other new crops and products suggests the impact that agricultural diversification might have. **Assuming the 150 million acres of excess capacity were employed to produce new products for industrial uses representing net new market demands, about $30 billion dollars of new farm income and 750,000 new (off-farm) jobs might be generated!**

Using a typical 2.75 multiplier to estimate the overall effect on economic activity, **the total benefit to the nation's economy could approach $100 billion per year**. Of course, the intangible social and other benefits of diversification would also be considerable. It is also noteworthy that the returns per acre could be expected to be higher from specialty crops than from commodity crops, like soybeans.

2. Revitalization of Agriculture

Diversification could lead to a revitalization of agricultural sectors currently under much stress. Being market-driven, diversification conceptually provides more options without requiring the dismantling of the present efficient production system for major commodities. If, for example, global demand for basic commodities unexpectedly increased beyond projections, production could be shifted back to maximize producers' returns. Given the responsiveness of annual crop systems, this could be accomplished rather expeditiously. Accordingly, **with increased crop and other product options, U.S. farmers could better respond to global market demands and opportunities**. With increasing sophistication, particularly in the use of information technologies, producers could more readily maximize their returns on a seasonal basis.

3. Increased International Competitiveness

Diversification could also be a key to increased national competitiveness. Under a diversification scenario, the most efficient, low cost producer segment of U.S. agriculture could be unleashed on global markets to maximize national shares of the residual world markets in major commodities. Other producers could concentrate on higher valued and more specialty products, wherein the economies of scale would likely be less important.

4. A Strengthened Economy

Diversification could also lead to a strengthened national economy. With all sectors of agriculture revitalized and productive, agriculture would remain the cornerstone for rebalancing trade, and ensuring the Nation's competitive leadership. Job growth and increased economic prosperity, arising from both diversification and productivity improvements in agriculture, could also be expected to substantially reduce the need for subsidies and price supports, and eventually enable their orderly phase-out.

On the Penalties for Inaction. . .
Upon reflection, one might conclude that the penalties for inaction on diversification may be as significant as the rewards for action. In spite of the soaring costs of government transfer payments, in the form of price support loans and direct cash advances, there currently appears to be little prospect for relief from increasing commodity stockpiles, family farm stress and tragedy, and international trade tensions. Consequently, **the potential social and economic costs of a continuation along the present path defy estimation**.

F. Past Barriers to Success

To define what must be done differently in the future, one must take advantage of the benefits of hindsight to develop an understanding of why past success was not achieved to the degree it might have been.

As expected, the Task Force found no simple explanation for the lack of large scale success in past attempts to diversify agriculture. However, the group did identify a number of factors which helped to explain why success was so limited in the past. The most notable factors identified were as follows:

1. No constituency or advocate.

There is considerable support for the premise that the lack of either an established constituency, or a credible and influential advocate for new product developments, has severely limited past progress toward diversification. Historically, major agricultural research funding has not been forthcoming until a new crop had already achieved a substantial production base, and thereby established a large constituency. Quite simply, diversification was handicapped by the fact that constituencies didn't exist for crops which didn't (yet) exist.

It is generally recognized that success in any developmental effort is largely dependent upon the existence of an effective product or project "champion". The Task Force found that rule also applied in the few examples of successful new crop developments (including the soybean). In a broad sense, **the lack of an effective champion for agricultural diversification can help explain the lack of consistency and commitment that are necessary preconditions for success**.

2. Inadequate and unstable research funding.

Historically, only a trivial proportion of agricultural research has been directed at the development of new crops and other new products. Since 1957, the Nation has invested less than one per cent of public sector research funding for agriculture to develop new farm and forest products. This inadequacy in funding support could be attributed largely to the absence of either a constituency or champion as suggested above.

Under the constraints of the normal budgetary process, **it appears unlikely that support for any specific agricultural developmental program or project can be sustained for the long time periods (i.e., decades) required for success.** This may be due in part to the lack of an effective long term, project management system to be able to plan, direct and monitor such long range research. Because of the need to ensure such long range programs are proceeding to meet identifiable and changing market needs, innovative management approaches are needed.

Superimposed over this funding allocation problem is the fact that the overall level of agricultural research spending represents only a very small fraction of the current Federal agricultural budget. This concern was emphasized by the Office of Technology Assessment which recently reported:

> ". . . .Research spending on agriculture is high throughout the world; indeed, the fraction of non-defense research spending on agriculture in Japan, France and several other nations exceeds that of the United States."

The Federal agricultural budget is of course primarily dedicated to transfer payments and other support programs. An analysis based upon plausible projections of such spending, and also historical crop development costs, suggests that **projected U.S. spending on farm income stabilization programs during the decade of 1982—1991 might have supported the development of the equivalent of more than 400 new crops.**

3. Dispersion of financial returns.

Although the overall rates of return to the nation for new agricultural developments are quite impressive, they are dispersed between producers, processors and consumers. Such a dispersion of returns and benefits dilutes normal market forces. Although industry's participation is essential to ensure products are developed to meet market needs, industry is inhibited from assuming a leadership role on its own. This is, in large measure, because industry cannot readily project its needed rates of return on investment due to both the dispersion of benefits and also the inordinately long time scales of agricultural developments. Given that consumers are primary beneficiaries of agricultural research and development, public investment in such areas seems particularly well justified.

4. Lack of market focus.

Until recently, even the limited public sector research allocations to new farm and forest products lacked mechanisms to be sure they merged with market needs. Developing products for which there is no market is, of course, not a formula for success. **Research on products and product-related technologies requires direct linkage with the marketplace in order for successful commercialization to proceed.** Historically, there has been no mechanism established to effectively link public sector research resources with market-oriented private sector resources. Indeed, until recent years, there were significant, purposeful barriers to such private/public sector cooperation in the United States. This was in marked contrast with the situations in Western Europe and Japan wherein close collaboration has been the norm.

5. Ineffective technology transfer.

Technology transfer is necessarily a vital step in the process of developing and commercializing new agricultural products. Under any circumstances, even within a single organization, technology transfer at the transitions between the stages in the innovation process is a challenging and difficult task. Inter-organizational technology transfer is even more complex, most of all when it is attempted between the public and private sectors.

The Extension System is a model vehicle for technology transfer to agricultural producers; however, there is no comparable system to link with industry during developmental stages. Although there are recent initiatives oriented toward this need, **historically there has been no effective mechanism to successfully manage technology transfer (and even cooperative technological development) between public sector research entities and industry in agricultural areas**.

In addition, only recently has multi-disciplinary research been emphasized. Development of new farm and forest products particularly requires multi-disciplinary approaches, and therefore requires coordination systems (and incentives) that have not been commonly used in agriculture.

6. High risks and long time scales.

Agricultural product developments, particularly those involving new or modified crops, require commitments over time periods which extend beyond normal commercial boundaries. Private sector investments require projectable rates of return and, as suggested above, projects, which require a decade or more to complete, rarely can be supported solely by private investments. This is particularly true in the absence of long term incentives, such as tax credits, or mechanisms for risk sharing. **The long time scales involved with agricultural developments suggest the need for innovative approaches to meet seed and venture capital needs—particularly ones which leverage both private and public sector funds and resources**.

G. Summary of Situation

Diversification of U.S. agriculture, to the extent needed to fully and productively utilize the Nation's capacity in agriculture and forestry, represents an extraordinarily formidable goal. However, it is one that the Task Force is convinced can be achieved—if the national will exists to achieve it.

Nonetheless, diversification will not provide a quick panacea for the current major problems facing the agricultural industry. **Developing products in harmony with market needs on a meaningful scale will require a major cooperative effort between the private and public sectors**. It will also require an orderly and coordinated mobilization, through reallocation, of the needed resources, and a long time to accomplish. Without such a commitment and mobilization against a well-conceived plan, diversification will simply not occur to any significant degree. In that case, there will likely be even more than 150 million acres of excess productive capacity available in the future.

The Task Force believes that the needed transformation for agriculture can be accomplished through an orderly redirection of existing priorities and reallocation of resources. **Although the strategic importance and magnitude of the task is comparable to those of prior national energy and space programs, the proposed program differs importantly from those others. The proposed agricultural program must clearly be market-driven and responsive to market considerations**. This suggests that, although a sustained significant commitment should be promptly initiated, redeployment of resources must be accomplished in an evolutionary and orderly manner as justified by appropriate combinations of: (a) technological leads; (b) defined market needs; and (c) organized collaborative programs between the private and public sectors to achieve specific objectives.

Development of production alternatives which are the equivalent of two or three soybean crops will likely require decades to accomplish. In fact, the history of the soybean example suggests something on the order of half a century would be needed. However, there is a basis for optimism that developments in the future will likely proceed at a pace which far exceeds anything in the past. For example, progress in world rice improvements resulting from only 25 years of focused interdisciplinary efforts compares quite favorably with the advances realized during the previous 5000 years. If the Nation can retain its leadership in the applications of biotechnology to agriculture, comparisons between future rates of progress and those of the recent past should also be quite impressive.

Such prospects suggest that a goal of developing the equivalent of a soybean crop in half the time of the historical soybean development appears within reach, and plausible. **Development of a total equivalent of two to three soybean crops would require substantial parallel development programs for a large array of crop candidates**. Nonetheless, attainment of such a national goal for agriculture and forestry would clearly establish the industries as cornerstones of American prosperity two or three decades in the future.

With that in mind, it is ironic to note that exactly 30 years ago the Task Group on New and Special Crops reported a positive response to the President's Bipartisan Commission on Increased Industrial Use of Agricultural Products. Had that report catalyzed action to achieve the results they intended, U.S. agriculture might be viewed with a much more satisfying perspective today.

III. CONCLUSIONS

Based on two years of investigations and analysis, the New Farm and Forest Products Task Force affirmed the following overall conclusion:

> Diversification represents the only response to the challenges facing U.S. agriculture and forestry which promises to enable both:
>
> (1) revitalization of ailing segments of the related industries; and
>
> (2) full realization of the great economic potential which agriculture and forestry hold for the Nation.

More specifically, the Task Force concluded that:

1. Significant opportunities do exist for U.S. agriculture and forestry to be diversified into new crops and other new products to meet real market needs - particularly for industrial, non-food uses;

2. Diversification of agriculture is a vital national need; and

3. Successful diversification of agriculture will require a major, long-term national commitment and innovative approaches which overcome past limitations and barriers to success.

Over the longer term, research and development emphasis on diversification into new products (including both new crops and new uses for existing crops) should gradually increase to a level at least equal to that placed on productivity improvements for existing crops.

It is noteworthy that although the Task Force had initially focused its attention on opportunities for plant-derived products, its conclusions and recommendations were subsequently found to be equally relevant to animal-derived products.

IV. RECOMMENDATIONS

Based on the findings and conclusions described above, the New Farm and Forest Products Task Force recommends adoption of:

a. Agricultural diversification as a national priority;

b. A proposed goal for diversification;

c. A proposed set of strategies to attain the goal; and

d. Proposed, specific action steps and initiatives directed at meeting organizational and resource-allocation needs for successful goal achievement.

A. A national priority

A national commitment should be made to agricultural diversification into new farm and forest products - particularly those which are directed at industrial market needs. This commitment must be manifested in actions which involve not only technological innovation, but also institutional innovation. In this regard, a key element of the Task Force's recommendations involves establishment of a Foundation for New Farm and Forest Products as outlined below.

Such a commitment to new products should address needs reflected in the other proposals. It also requires an orderly rebalancing of research priorities and resources between the development of new farm and forest products, and that of productivity improvements and cost reductions for current crops. The need for an orderly reallocation of financial resources from current transfer payment programs to appropriate research and development programs is also indicated.

B. A national goal

The Task Force recommends adoption of the following specific National goal:

To develop and commercialize, within the next 25 years, an array of new farm and forest products utilizing at least 150 million acres of productive capacity to meet market needs representing net new demand for agricultural and forestry products.

Shorter term goals should also be defined based on a comprehensive assessment of the current opportunities and technologies available.

As suggested in the discussions above, such a 150 million acre usage goal represents the equivalent of two to three new soybean crops and the amount needed to adequately utilize the Nation's excess productive capacity. In the opinion of the Task Force, such a quantified goal is meaningful, appropriately challenging, and also plausibly attainable.

C. Strategies

Based on its findings, the Task Force believes achievement of the proposed national goal will be dependent upon successful implementation of the following strategies:

1. Increase national emphasis on, and reallocate existing resources to the development of new farm and forest products, particularly those which serve as industrial raw materials;

2. Establish a broad nationally-based understanding of the critical role that agriculture and forestry play in the health and wealth of the Nation, and a consensus that diversification of agriculture and forestry should be a national priority;

3. Establish mechanisms to increase private/public sector collaboration and cooperation in the development of new farm and forest products;

4. Establish mechanisms to facilitate agricultural technology transfer, particularly between the public research and private industrial sectors;

5. Ensure that responsible biotechnological developments can proceed at a rate which retains national leadership in agricultural applications; and

6. Establish an organized program to identify opportunities to provide appropriate incentives for, and reduce barriers to development of new farm and forest products.

The following amplifying comments are pertinent to consideration of these strategies.

1. New Product Emphasis.
This strategy is, of course, central to goal achievement, and the other strategies may be viewed as supportive (albeit in some cases prerequisite). Recognition of both the needs and opportunities to diversify agriculture has been documented over decades. However, as previously indicated, new crop and product development has historically received only low levels of funding support - and then only on an erratic basis. Development of new agricultural products and diversification of U.S. agriculture will simply not occur at a meaningful rate unless there is an increased and sustained commitment to such a program accompanied by an adequate reallocation of resources.

2. National Understanding.
Attainment of the proposed diversification goal will require a substantial and sustained national commitment - a commitment which in itself will be dependent upon establishment of a supportive national consensus. Judgmentally, attainment of such a consensus will require policy-makers, educators, researchers and the general public to become better informed about both the importance of agriculture and forestry to the Nation, and also the specific character of these industries. The importance of implementing this strategy was underscored by Professor James T. Bonnen of Michigan State University who stated:

> "Agricultural sector political power would appear inadequate to sustain a modern, balanced science base for agriculture. . . As a consequence, as long-term steady support for agricultural science research has become absolutely critical to the future of an industrialized agriculture, the fragmentation and narrowing of the economic interests in agriculture make it increasingly difficult to mobilize support for long-term goals."

Farming seems to be regarded by the general public with nostalgia and an abstract form of empathy; however, the kind of informed understanding needed for a consensus on establishing agricultural diversification as a national priority seems to be missing. To fill this gap in understanding, a substantial effort in educational, informational and promotional areas will be required.

3. Private/Public Sector Collaboration.
Because of the complex nature of the agricultural and forestry industries, and the diffusion of returns from them, success in achieving the proposed goal will be highly dependent upon the establishment of effective collaborative efforts between the private and public sectors. Cooperation and dialogue between industry, government, and academia will be essential for meaningful and timely progress to be made. Cooperative funding for related research efforts should be encouraged to leverage the investments from each sector, and also share the risk. Importantly, such cooperative funding also virtually compels an increased level of dialogue and collaboration between the involved organizations. Established mechanisms are also needed to mobilize the resources of industry, government, and academe to address urgent issues and undertake specific tasks and objectives of national priority.

Dr. G. A. Keyworth II emphasized the point when he was Science Advisor to the President:

> "The. . .goal of science policy, stimulating partnerships among scientists and engineers in universities, federal laboratories, and industry, reflects the pressing need to improve the transfer and application of new knowledge to national needs, particularly in industry. . . .Better partnerships are clearly needed in the field of agriculture."

It should be noted that experiences, in other fields of technological development, suggest cooperative development programs are likely to be most effective if approached on a problem-oriented, multi-disciplinary basis.

4. Improved technology transfer.
Mr. Robert M. Coulton of the National Science Foundation describes technology transfer as:

> ". . .a process of information movement and utilization, whereby scientific and engineering knowledge is ultimately converted into marketable products, processes, and services."

Drs. Roy S. Rauschkolb and L. W. Dewhirst of the University of Arizona stated:

> "The term 'technology transfer' implies a basic premise that technology or knowledge has some application for the benefit of mankind, therefore making the transfer of it desirable. . . it occurs along a continuum of development and application from the initial conception of the idea or hypothesis to the final application and adoption."

As discussed above, technological innovation involves long odds against success. This suggests a reason for limited commitments and records of success in technology transfer activities. In the words of Mr. Charles D. DesForges of the Research Corporation Limited in the United Kingdom,

> "Technology transfer alone is not a profitable business for either individual universities or industry. Specialized organizations acting in the public interest, which can examine a large number of disclosures, seem to be the only ones capable of bearing the risk of the statistically poor chances of an invention covering overhead costs, let alone making surpluses."

Two particular categories of technology transfer warrant additional consideration and comment.

a. Between Public and Private Sectors. Because of the breadth of agricultural research across both private and public sectors, effective inter-organizational technology transfer is critical to achieving any meaningful progress in commercializing new agricultural products. Nonetheless, technology transfer between government and industry is an exceedingly difficult task. Importantly, although it has been treated as such in the past, the process is not one of a sequential and unidirectional "technological baton passing". Rather, as suggested above, it must necessarily be a continuous process. Direct contact and dialogue, between the involved individuals and organizations, must be maintained throughout the entire development process. Although the Extension Service provides an excellent model for technology transfer to the farming community, a parallel function for transfer to industry has not been developed or practiced.

b. Between International Institutions. Because the development of new agricultural products and related technologies is being emphasized throughout the world, developmental programs should also encompass elements of international cooperation. The existence and importance of multi-national corporations also makes such programs necessities. Fortunately, when adopted on a selective basis, international cooperation can lead to acceleration of the development process, without compromise of international competitiveness. In today's world wherein the rate of global diffusion of technology is so rapid, international cooperation in developmental areas appears to offer much more upside potential for gain, than downside potential for loss. In the words of Mr. G. Edward Shuh of the World Bank,

> "We desperately need to shift our perspective from the present one, in which we view doing research on and in other countries as being mainly beneficial to the other country, to one in which we view it as being in our best interest. To be effective in these activities we need to build longer-term relationships with institutions in other countries, with the dual objectives of doing joint research that is in the interest of both countries."

5. Application of Biotechnology.
As discussed above, agriculture is an industry based on biology and its future largely depends upon biotechnological developments. It is important to note that there is a long established history of experience for biological manipulation in

agriculture. In spite of the randomness of the historical processes, the record is one of unblemished, socially responsible progress.

By providing the technological means to accelerate the process, and actually improve its precision, modern biotechnology appears to offer the means to dramatically accelerate future developmental progress, with much more predictability and control than in the past. Because biotechnology offers the promise of transforming agriculture, in terms of diversity and efficiency, it must be seen as a vital key to future competitiveness for U.S. agriculture and forestry.

As suggested above, the prospects for biotechnology to transform agriculture, into a dramatically more diversified and efficient industry, now appear virtually limitless. However, there are remaining questions of timetable and international leadership. A specific and imposing question is: Who among the countries of the world will lead in commercial agricultural applications, and thereby reap the most benefits for their society?

The United States currently is the world leader in biotechnology; however, several other countries, particularly Japan and members of the European Economic Community, have made major commitments to such areas of research and development, and are not far behind. Consequently, despite this current position of leadership, there appears to be a distinct risk that the U.S. could well become a laggard practitioner of its own technology. This of course has already happened in other technological areas related to manufacturing industries.

Regulatory and legal complexities/uncertainties have substantially slowed vital testing, and application of new biotechnological developments, within the existing framework of domestic agriculture. Consequently, other countries appear to be better poised to exploit the developments of U.S. biotechnology, and may achieve early advantages denied to U.S. industry. Dr. Keyworth captured the situation when he wrote:

> "There is little question but that we have made only slow progress in bringing the benefits of the modern biotechnology revolution to American agriculture. The result is that we have failed to take the prudent steps necessary to protect the enormous world leadership that we have enjoyed for so long in agriculture. . . .We have already seen - painfully - how aggressive competitors who adopt new technologies and run with them can make severe inroads into what American industry assumed was a guaranteed market. . . . We would hate to add agriculture to that list 20 years from now."

Similarly, the Office of Technology Assessment summed up the situation in a recent report which said:

> "Many new technologies, particularly biotechnologies, raise unique problems that require a balance between the benefits of research, development, and fielding of new technologies on the one hand, and the interests of public health and safety on the other. A mechanism for dealing with these issues in a fair and expeditious way would facilitate agricultural research and development."

6. Incentives and Barriers.

As already stated, U.S. agriculture is an enormously complex and ponderous industry which delivers economic and other benefits in a diffuse manner across all groups of society. Frequently the primary beneficiaries of investments in agriculture are consumers and groups other than those making the investments. Consequently, an organized program is needed to identify and advocate the establishment of appropriate incentives and reduction of the barriers.

Examples of such incentives could include: appropriate tax credits for high risk, long range research and development programs; authorization of set-aside acreage use to grow demonstration quantities of developmental crops; and provision of payment guarantees to farmers for production of experimental crops. Judmentally, an objective organization, which does not carry the burden of beneficial self-interest, would have more credibility and be much more effective in identifying and promoting such changes.

D. Initiatives

The New Farm and Forest Products Task Force has defined, what it believes is, a set of action steps and initiatives to responsibly implement the above strategies, and effectively move toward attainment of the diversification goal for U.S. agriculture and forestry. Although each separate proposal is considered to be meaningful and important, the Task Force views one of its proposed initiatives as paramount and critical. This proposal may also be viewed as a mechanism to implement the other proposed initiatives.

1. The Primary Proposal: Establishment of the Foundation for New Farm and Forest Products

The Task Force considers the establishment of an independent organizational entity, dedicated to achievement of the diversification goal as absolutely vital. As a general principle, any substantial goal can only be achieved if a properly structured and supported organization is established with a dedicated mission, and adequate resources, to reach the goal. Such an entity must be established in a framework which enables it to be not only independent (although highly accountable), but also credible and effective in both the private and public sectors. It must necessarily establish itself as a central focal point, advocate and catalyst for new farm and forest products. To this end, the Task Force strongly recommends establishment of the Foundation for New Farm and Forest Products.

Organization and Structure

An appropriate organizational entity is described in an appended draft legislative bill proposed for its formation. It is intended to be a relatively small organization in terms of staff size and administrative expenditure. To be effective, it must be the kind of assertively proactive, energetic and productive organization that appeals to, and draws upon, the best human talent available in the Nation.

To prevent the Foundation from evolving into a large bureaucratic organization, appropriate constraints on administrative spending must be established which are proportional to the scope of its responsibilities and the magnitude of the resources it controls. Nonetheless, since the effectiveness of the organization will largely depend on the quality of the people in it, due consideration must be given to providing adequate compensation to superior performers and achievers. This suggests the constraints be more focused on limiting organizational size, not performance-based individual compensation. In particular, individual incentives should be provided to reward delivered results, particularly achievement of notable goals.

As a relatively small organization, the Foundation would necessarily need to work closely and cooperatively with the existing relevant organizations in both the private and public sectors. Indeed, in the opinion of the Task Force, unless such a new organization (big or small) effectively builds on, and enhances the effectiveness of existing organizations and programs, it will fail to accomplish its mission. This premise underlies the Foundation proposal.

Mission and Purposes

As conceptualized, the Foundation would be an autonomous, non-profit corporate entity which has a mission to foster and facilitate the development and commercialization of new farm and forest products. Under the proposal, it would be specifically charged with the responsibility of achieving the stated, quantified goal for diversification of U.S. agriculture and forestry. It also should be charged with the responsibility to facilitate the commercialization of relevant USDA research results - that is, to effectively become the commercial arm of the U.S. Department of Agriculture.

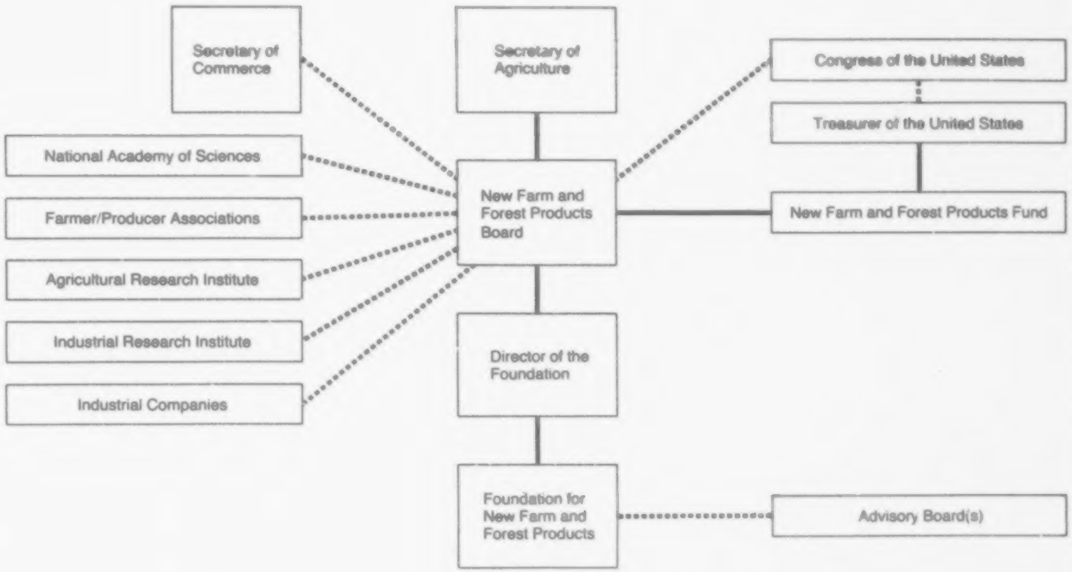
Role and Operations

As indicated above, the Foundation would have primary responsibility for developing and implementing a strategic plan to achieve the national diversification goal. To accomplish such a mission, the Foundation would undertake the roles suggested by the Council for Agricultural Science and Technology for such an organization. One of those roles would be that of identifying and advocating changes which provide incentives for, and reduce barriers to, diversification of U.S. agriculture and forestry. Additionally, in cooperation with other organizations (specifically including the Agricultural Research Service, the Agricultural Research Institute, and the Industrial Research Institute), the Foundation should seek to organize and conduct annual conferences on agricultural diversification.

More importantly, the Foundation would need to be centrally involved in the screening, selection, and financing of cooperative private/public sector projects and joint ventures. To fulfill its multiple roles, it would of course need to build strong direct working linkages with existing organizations having overlapping interests. These organizations should specifically include: the USDA's National Agricultural Library and Office of Critical Materials; the Agricultural Research Institute; the Industrial Research Institute; and the National Association of State Universities and Land Grant Colleges.

Although establishment of a separate entity to act as the commercialization arm for USDA research could be considered, such functional responsibilities should be incorporated within the Foundation. However, if separate entities are established

Structure and Organization: Foundation for New Farm and Forest Products


Secretary of Commerce
Secretary of Agriculture
Congress of the United States
Treasurer of the United States
National Academy of Sciences
Farmer/Producer Associations
Agricultural Research Institute
Industrial Research Institute
Industrial Companies
New Farm and Forest Products Board
New Farm and Forest Products Fund
Director of the Foundation
Foundation for New Farm and Forest Products
Advisory Board(s)

for each purpose, there must be common overlap between the management and advisory boards of each, to ensure that a high level of cooperation and coordination is achieved between them.

Funding
The Foundation must be funded in a manner which provides the long-term stability and resources needed to achieve success. Financial stability is particularly needed to enable the kind of independence required for the entity to be successful, and also to provide a continuing, predictable source of seed and venture capital funding. Such an entity should develop supplementary funding from private sources, and ultimately become self-funded through returns from successful projects it sponsors. However, given the timescale of agricultural developments, attainment of such a self-funding status will take many years. Accordingly, because its mission is clearly in the national interest, it should be initially funded through a trust fund established by the Federal Government.

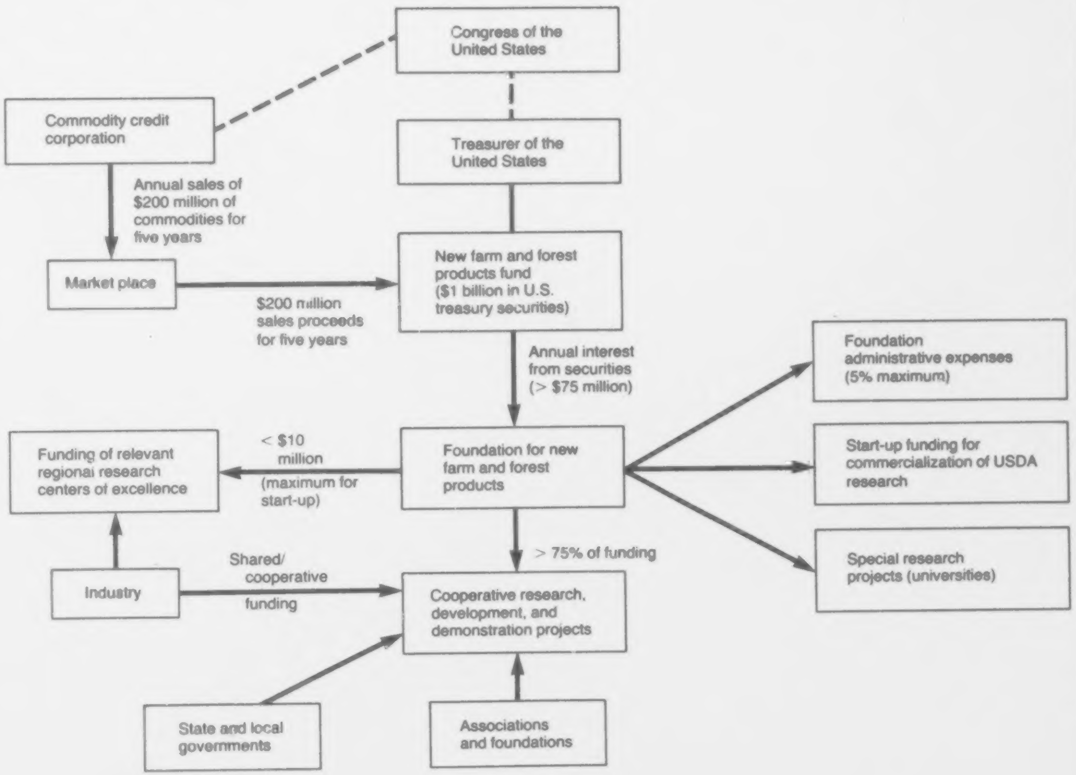
Establishment of a trust fund is key to enabling successful accomplishment of the Foundation's mission and goal. Without a trust fund basis, excessive diversion of Foundation resources would be needed to merely ensure continuing budget support - thus severely detracting from the efficiency of the organization. Dependence upon traditional budgetary processes could also compromise the objectivity and independence needed for the Foundation to be effective. Of course, mechanisms would need to be established to not only ensure appropriate accountability for Government funds, but also accountability for performance in terms of results and goal achievement.

The magnitude of the task to diversify American agriculture by attaining the specific diversification goal dictates the need for a significant investment. Accordingly, **the Task Force recommends that the Foundation be initially funded by proceeds from a $1 billion trust fund, established by the sale of $200 million of various commodities held by the Commodity Credit Corporation each year for a five year period.** As proposed, the funds would be invested in U.S. Treasury securities. When fully established should generate an annual interest income of over $75 million.

Operational and administrative costs should be held to less than five per cent of the annual funds available. The vast majority of funds should be allocated to investment in carefully evaluated and selected research and development projects. As conceptualized, such project investments should only be made on a leveraged basis with both private and other public sector participation. (Such participation would significantly help to ensure the commercial relevance of the research and development work supported.) In addition, provision should be made for royalty returns to the Foundation from successful projects. Provision would also be made for the trust fund to revert back to the Federal Treasury as royalty revenues developed, but no later than twenty years from establishment of the fund.

Prior organizational models, such as the Department of Commerce BIRD program described below, suggest that $100 million is the minimum needed to establish a trust fund suitable for an entity of the character of the Foundation. However, the

Suggested Funding and Disbursements of Funds: Foundation for New Farm and Forest Products


Congress of the United States
Commodity credit corporation
Treasurer of the United States
Annual sales of $200 million of commodities for five years
Market place
$200 million sales proceeds for five years
New farm and forest products fund ($1 billion in U.S. treasury securities)
Annual interest from securities (> $75 million)
Foundation administrative expenses (5% maximum)
Funding of relevant regional research centers of excellence
< $10 million (maximum for start-up)
Foundation for new farm and forest products
Start-up funding for commercialization of USDA research
> 75% of funding
Special research projects (universities)
Industry
Shared/ cooperative funding
Cooperative research, development, and demonstration projects
State and local governments
Associations and foundations

magnitude and strategic importance of the task to diversify American agriculture suggests such a fund would be inadequate. Although the lower level of funding would support a catalytic organization, which could fill certain roles specified for the Foundation, the funding would clearly be insufficient to permit the entity to be charged with responsibility, and held accountable for attainment of the diversification goal. Although not recommended by the Task Force, if such an alternative approach were taken, the smaller $100 million trust fund might be allocated by a one-time diversion of $100 million from current commodity programs. In percentage terms, such a single diversion would represent only a very small redirection from current commodity and transfer payment budgets.

Regardless of source or amount allocated, the trust fund investment could properly be viewed as consistent with the strategic purpose of the current payment programs - to help ensure the (future) financial viability of farm producers. A relatively minor deduction from such current programs offers the potential for immense future returns to both producers and also to the Federal Government itself. (Governmental returns would result from the effects of successful diversification, which should not only reduce needs for future transfer and support payments, but also increase the economic tax base of the agricultural sector.)

Building Blocks for the Foundation

The need for such a Foundation is recognized by prior studies, and the concept is based upon proven operational models. There are several particularly relevant building blocks upon which the Foundation was modeled - each of which is, in itself, built upon much prior learning and study. They are as follows:

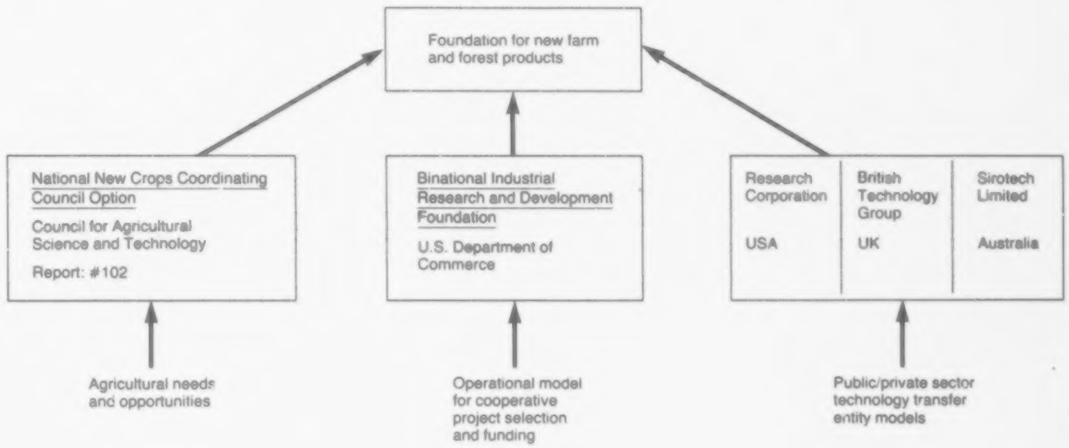
(a) a previous task force report option from the Council for Agricultural Science and Technology (CAST); (b) an operating, organizational model developed and implemented by the Department of Commerce for the Binational Industrial Research and Development Foundation (BIRD-F) program between the United States and Israel; and (c) both domestic and overseas technology transfer entities, particularly the Research Corporation USA, the British Technology Group, and SIROTECH Limited.

A. CAST Task Force Analysis

CAST Report No. 102 was entitled "Development of New Crops: Needs, Procedures, Strategies and Options". In response to a request by the Joint Economic Committee of Congress, the reported study probed related history and issues, and outlined a number of options to address the organizational needs to foster and promote the development of new crops. In the view of the Task Force, the options also could be seen as equally relevant to the development of new uses for existing crops and other new products. (Although not necessarily easier to accomplish, these latter categories are actually easier to support because of the existence of established constituencies.)

One of the options presented by the CAST report involved the establishment of an entity titled the "National New Crops Coordinating Council". This option was described as an independant, joint government-industry entity which would do the

Building Blocks for the Foundation


Foundation for new farm and forest products
National New Crops Coordinating Council Option
Council for Agricultural Science and Technology
Report: #102
Binational Industrial Research and Development Foundation
U.S. Department of Commerce
Research Corporation
USA
British Technology Group
UK
Sirotech Limited
Australia
Agricultural needs and opportunities
Operational model for cooperative project selection and funding
Public/private sector technology transfer entity models

following: (a) serve as a clearing house for information; (b) maintain a directory of individuals and organizations related to new crop interests and activities; (c) sponsor workshops and conferences to increase awareness, stimulate interest, and promote new crop developments; (d) assist researchers in obtaining financial support, and entrepreneurs in identifying potential partners and funding sources; and (e) promote identification and establishment of appropriate incentives for new crop research, development, and commercialization.

B. BIRD Foundation Model

The BIRD-F program was organized by the U.S. Department of Commerce in 1978 to facilitate the development and commercialization of new products and technologies through binational private/public sector collaboration. Structured as a non-profit, autonomous corporate entity, the functional BIRD-F organization is a small one - only about six staff people. The role of the BIRD-F office is to coordinate analyses of opportunities and selection of projects for support on the basis of merit and potential. Importantly, the BIRD-F office is able to accomplish these roles with limited staffing because: it utilizes state-of-the-art evaluation techniques, and also, it coordinates and draws upon substantial resources within the agencies of each government. These include the U.S. Federal Bureau of Standards (for technical evaluations) and the U.S. Department of Commerce, as well as comparable Israeli agencies.

Entrepreneurial in character, the BIRD-F office facilitates the establishment of international joint ventures (admittedly the most complex of all joint ventures), particularly between small and medium size companies in each country. Using income from its trust fund, the office also assists in funding projects on a matching support basis with the private sector commercial venture partners. Investments are made in a manner which leverages private capital, shares risks, and provides for royalty returns to the BIRD-F fund from successful projects. Importantly, the BIRD-F office was provided with a trust fund of $110 million to provide seed and venture capital for selected projects. Although modest in scale compared to what is needed for agricultural diversification, the results achieved by the BIRD-F program are impressive. From 1978 through 1986, the office had selected and funded 135 projects with 54 reaching commercialization. The latter group has generated cumulative sales revenues of over $250 million, and royalties in excess of $2.5 million. An overall success rate is expected to be well over fifty percent. In view of traditional low success rates, such results would indeed be impressive.

Obviously, the effectiveness of a small organization, such as the BIRD-F office, is highly dependent upon the quality of the people involved (and their ability to tap extensive resource networks). Nonetheless, the BIRD-F operation has achieved a successful track record and does provide a proven and effective organizational model upon which to build.

C. Technology Transfer Entities

There are many examples of different types of entities which serve as technology tranfer vehicles both in the United States and overseas. Domestic entities include the Research Corporation USA, University Technology, Inc., a non-profit subsidiary of Case Western Reserve University, and the Center for Biotechnology Research, a non-profit corporation associated with Stanford University, the University of California at Berkeley, and the Massachusetts Institute of Technology. Particularly relevant overseas initiatives include the British Technology Group (BTG) in the United Kingdom and SIROTECH in Australia. Several of these provide useful perspectives pertinent to the Foundation proposal.

Research Corporation USA
This corporation is a private foundation created in 1912 to advance basic science and technology by generating funds for a grants program through technology transfer activities. Although relatively modest in scale, the Research Corporation generates an annual royalty income of $10 million out of services provided to 300 U.S. institutions.

British Technology Group
The precedent organizations upon which the British Technology Group (BTG) was organized were established over 25 years ago. Originally commissioned to broker public sector technology, the organization received over 50 million British Pounds Sterling in funding over a period of years. Based on royalties received from successful technology transfers, BTG long ago paid back the initial investment, and today generates an annual revenue of about 25 million Pounds Sterling.

SIROTECH Limited
Although more limited in history, SIROTECH is quite relevant as a model for technology transfer between Federal Government research laboratories and the private sector. SIROTECH Limited is a statutory body, structured as a non-profit company. It serves as the marketing and technology transfer arm of the Commonwealth Scientific and Industrial Research Organisation (CSIRO), the principal Australian Federal Government's research organization. CSIRO is structured simil~~ar to the~~ Agricultural Research Service (ARS) with geographically dispersed research laboratories focused on specific missions. With an overall research budget comparable to that of ARS, CSIRO's research encompasses very diverse categories of technology - although a substantial portion of it is dedicated to agriculturally-related sciences.

Having only been founded in 1984, SIROTECH has already established itself as an effective vehicle for facilitating technology transfer and commercialization of the research results generated by CSIRO. SIROTECH's results are indicated quantitatively in the following financial terms (in U.S. dollars).

a. Royalties. Since 1984, royalty revenues from licensing patented CSIRO technologies have jumped from an annual rate of less that $140,000 to over $1 million.

b. Current Contractual Income. Under contractual arrangements with private industry, much research work within CSIRO is now funded from outside. The funding levels have jumped nearly three-fold since CSIRO was formed - from less than $3 million in 1983/84 to over $8 million in 1986/87.

c. Assets. On behalf of CSIRO, SIROTECH currently holds equity in joint venture companies. The value of this portfolio now exceeds $12 million. Formation of such joint ventures with private sector companies was fostered by SIROTECH to commercialize research results from CSIRO. The equity represents the return to date on such research results, and provides the basis for future self-funding and investment seed capital for new ventures.

SIROTECH is funded by a retainer fee from CSIRO under contract between the two organizations. Based on the results to date, it appears that CSIRO is receiving an excellent return on its investment of less than $1.5 million per year in retainer fees, with even greater returns expected to be generated in the near future.

2. Other Proposals

As stated above, the Foundation proposal is considered by the Task Force as essential to establishing a national commitment to, and achieving the goal of agricultural and forestry diversification. Although the Foundation itself could serve as the organizational instrument to implement the other initiative proposals, they also can be considered independently. These proposals are as follows:

a. Establishment of a Commercialization Entity for U.S.D.A. Research

If such a role is not incorporated within the scope of responsibilities of the Foundation, the Task Force proposes establishment of a non-profit corporate entity similar in structure to the Foundation proposed above, but with the specific mission to facilitate the commercialization of market-relevant USDA research results.

As suggested by the discussions above, new approaches are needed to improve the process of bringing scientific discoveries from the public laboratory to the marketplace. Although new technology transfer mechanisms can be expected to enhance utilizations in all areas of agricultural research, they are particularly needed for the development of new farm and forest products.

Of course, the Department of Agriculture has recognized this general need, and already established certain policies and programs to increase collaboration with industry, and promote the commercial utilization of its research findings. Examples include the establishment of the Office of Critical Materials within the USDA, and establishment of an interactive dialogue between the Agricultural Research Service and the Industrial Research Institute. Although these initiatives do begin to address certain aspects of the technology transfer process, their intended purposes and functional roles are quite limited, and are distinct from those of the proposed entity. Nonetheless, the proposed new entity (whether incorporated within the Foundation or separately structured) would be expected to work closely with, and enhance the effectiveness of the initiatives already in place.

Because private/public sector technology transfer is both important and difficult, it has received much attention in recent years and been the subject of research and experimentation throughout the world. Accordingly, as indicated above, the Task Force drew upon global precedents and demonstrated models to define the concept of such a technology transfer company (TTC).

As an autonomous company, the TTC should be able to interact with private industry, and directly engage in necessary business activities, in a much more efficient and effective manner than would be possible for a government agency. Examples of such activities could involve direct equity participation in joint ventures with private companies.

Because of its "quasi-private industry" character, the TTC could readily access and engage top marketing talent from the private sector on market competitive and performance-related terms. However, as a non-profit company which is closely linked with, and accountable to, the USDA, it should enjoy a high level of credibility and access in both the private and public sectors. (This has been the observed situation with other similarly structured entities, and is seen to have substantially contributed to their effectiveness.) Importantly, it would be structured to build upon the policies which increase the independence of regional USDA laboratories, and facilitate their closer linkage with industry. As previously suggested, it would also need to work in a closely coordinated way with the Foundation (if separated as an initiative) and other relevant agencies, such as the Office of Critical Materials.

Although the SIROTECH model suggests the appropriateness of a higher funding level, other models, such as BIRD-F office, indicate that an annual budget of about $500,000 could be sufficient to initiate such an organization. However, such a funding level would require additional USDA "in-kind" support, such as office facilities and support services. Based on the SIROTECH model, a contractual relationship between the USDA and the TTC organization would seem to be appropriate. Relevant experiences with similar organizations suggests that the TTC could be expected to ultimately achieve total self-funding while providing royalty revenues to the USDA.

If, as the Task Force recommends, the technology transfer function is incorporated within the scope of responsibilities and roles of the Foundation for New Farm and Forest Products, no additional allocation of funds would be needed.

b. Establishment of Multidisciplinary "Research Centers of Excellence"

Establishment of several National Centers of Excellence is proposed to focus on research particularly oriented to technologies for new farm and forest products. Modeled after the NSF-sponsored Engineering Research Centers, these collaborative industry/academia centers could be located within selected Land Grant Universities. They should involve several institutions, and be established as cooperative regional centers of excellence in specific categories. Importantly, participation of non-Land Grant Universities, and also departments outside of traditional agricultural disciplines, should be encouraged.

Bringing together industrial and multi-disciplinary academic resources, such centers have proven to be effective vehicles for stimulating industry/university collaboration, and facilitating technology transfer in other areas. Of particular note, such centers also serve to promote temporary or sabbatical exchanges of scientists between industry, government, and academia. Their relevance to agriculture has been suggested by others, such as Mr. Alvin L. Young of the President's Office of Science and Technology Policy, who stated:

> "These centers would address opportunities in research and training and would establish foci for industrial, other private sector, and local and state government participation. . . .The centers concept is especially appropriate for the emerging high technology areas of agricultural research."

Under this proposal, the agricultural centers could be focused on research in such subject areas as: agriculturally-based industrial raw materials; bioprocessing and bioengineering; pharmaceuticals and other biologically-active substances from agriculture; and integration of plant breeding & genetic engineering. Based on the NSF model, funding of about $10 million over five years would support the establishment of about six centers.

Such an initiative might appropriately be undertaken as a cooperative program between the USDA and the National Science Foundation, or directly sponsored by the Foundation. Importantly, this proposal is consistent with the Science and Technology Center element included within the President's Competitiveness Initiative of 1987. It is also consistent with elements of the Five Year Plan For Food and Agricultural Sciences proposed last year by the Joint Council on Food and Agricultural Sciences. The latter plan included recommendations for increased use of multidisciplinary research grants - which would be of sufficient magnitude to catalyze formation of the proposed centers.

c. Establish International Cooperative Development Programs

The Task Force proposes establishment of specific and selective international programs to develop new farm and forest products and related technologies, particularly those which are focused on the development of industrial raw materials. Specifically, **the Task Force recommends initiation of suitable programs under the guidelines and mandates of the Critical Agricultural Materials Act of 1984, PL-98284.** Such programs could include exchanges of scientific personnel, technical data and germplasm, and establishment of developmental joint ventures as specified within the Act. Although the Act's provisions currently only specify such programs with the countries of Australia, Israel, and Mexico, the program could be expanded to include other selected countries if warranted by initial results and experiences with the specified countries.

As indicated above, international cooperation has the potential to accelerate the development of new farm and forest products and other new agriculturally-related technologies. Although there have been historical programs of cooperation, these have largely been oriented toward assisting developing countries. In the context of agricultural diversification, new emphasis should be placed on programs specifically selected to provide balanced, mutual benefits for each participating country and agency. Programs which internationally link both private and public sectors are likely to be of most value in facilitating the development of new farm and forest products.

As indicated above, such cooperative international development programs with several countries are already encouraged under the Critical Materials Act of 1984. They are also encompassed within recommendations under the Joint Council's Five Year Plan cited above. The Joint Council's recommendations particularly encourage expansion of personnel and technical information exchanges under the auspices of the U.S. Extension system. It is noteworthy that such expanded international programs could also facilitate implementation of the element of the President's Competitiveness Initiative which calls for development of mechanisms "to ensure that information on foreign research is made available in a prompt and efficient manner".

If established in the framework of the existing programs of the USDA's Office of Critical Materials and the Office of International Cooperative Programs, such initiatives could be implemented with only modest incremental additions to existing budgets.

d. Establishment and Support of Specific Task Force Efforts

The Secretary's program of Challenge Forums has proven to be an excellent means of providing focus on major issues and catalyzing voluntary follow-up action. However, there remain needs for addressing specific tasks which do not warrant Challenge Forum attention. In addition, task forces which are oriented to implement, rather than propose action, require support and organization which go beyond the precedents of the Challenge Forums. Specifically, the New Farm and Forest Products Task Force proposes the following additional task force initiatives to address specific needs.

(1) Biotechnology

To begin to implement the related strategy cited above, a task force should be formed to address the issues related to ensuring national leadership in agricultural applications of biotechnology. Hopefully, such a task force will evolve from the recent Challenge Forum on Biotechnology. However, if this does not happen, one should be specifically organized - perhaps under the joint sponsorship of the USDA and relevant biotechnology associations, as well as the Agricultural Research Institute and the Industrial Research Institute.

(2) Agriculture Information and Promotion

To implement the related strategy, a task force, drawing from appropriate private and public sector organizations, should be convened with a mission to develop and implement a national educational and promotional program for agriculture. The Task Force should seek to provide the needed information and perspective to the general public, as well as the decision-makers and scientific communities in industry, academia, and government. Its program should be focused on providing factual information, and a properly balanced perspective on the scope and role of agriculture in the Nation's health and wealth, and also the potential importance of agricultural diversification.

The program could appropriately be coupled with elements of the Hatch Act Centennial program since the objectives of both programs are complementary and in the public interest. The specific program proposed should include: the organization of national conferences; preparation of literature for public information; organization and coordination of papers for publication and other media coverage; and other direct promotional activities. Such promotional information should also encompass material suitable for use by land-grant administrators, scientists, teachers, and extension personnel in their areas of responsibilities. Primary funding for the effort should be solicited from private associations and foundations, although cooperation of governmental entities should be evident.

Although timeliness of such an endeavor is important, such a new task force initiative could be appropriately organized and led by an organization such as the Agricultural Research Institute or the proposed Foundation for New Farm and Forest Products. In any event, such a program needs to be undertaken as a private and public sector collaborative effort, preferably through the direct involvement of associations, foundations, and industrial groups. These should specifically include the Agricultural Research Institute, the Council for Agricultural Science and Technology, the Industrial Research Institute, and the Joint Council on Food and Agricultural Sciences.

In addition to helping to build the national consensus needed to translate ideas into action, this initiative would also encourage entry of students into agriculturally related fields, and promote increased collaboration with organizations and disciplines outside of traditional agricultural areas.

(3) Extension Service for Industry

As already acknowledged, the U.S. Extension Service provides an exemplary model of effective technology transfer at the particular interface between the technologist and the primary producer. Nonetheless, there is an increasing need to develop improved technology transfer mechanisms at other interfaces, particularly with small to medium sized companies in industry. Many of the developmental programs for new farm and forest products are progressing with the support of such smaller, entrepreneurial companies. Accordingly, there is an increasing need for establishment of some mechanism to link those smaller companies with public research institutions. Assessment on whether and how the Extension Service might undertake such a mission would seem to warrant investigation and assessment by a properly constituted task study group.

(4) Implementation Task Forces.
At a 1986 workshop sponsored by the Agricultural Research Institute, it was recognized that:

> "No mechanism seems to exist to focus the researchers, or other appropriate personnel, on needs identified in a whole agricultural system aimed at really solving a specific major problem in a given time frame."

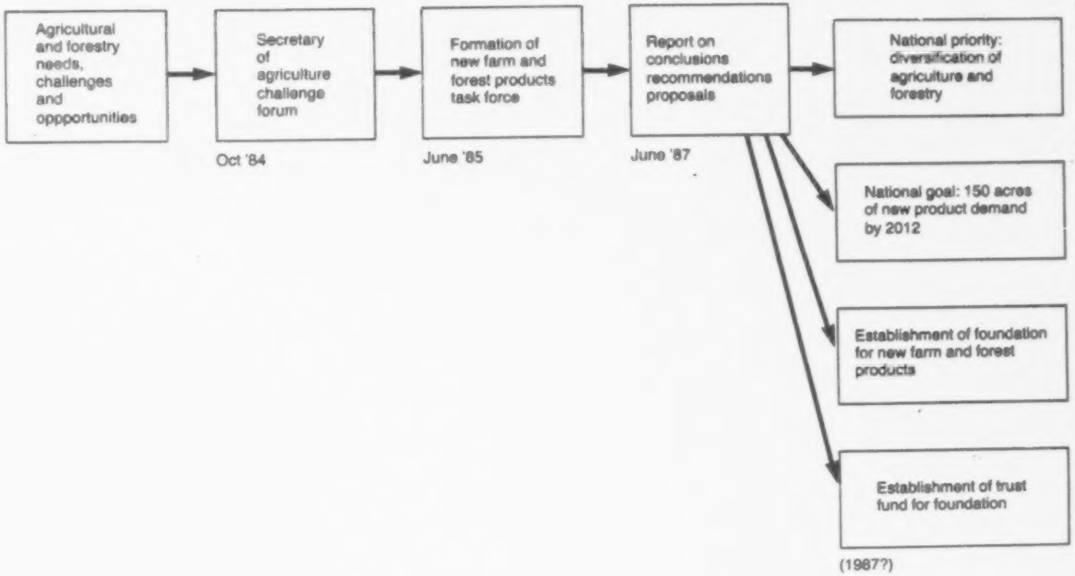
Consequently, a workshop group proposed that:

> ". . .a mechanism be established under the direction of the Secretary of Agriculture to coordinate on a national scale objective-oriented research tasks and responsibilities for a few major identifiable projects in a specific time frame."

An example offered for such a task force objective was the establishment of an objective to increase the export of U.S. beef by one million tons per year within ten years.

The New Farm and Forest Products Task Force agrees with this proposal. Indeed, the Foundation proposal in itself represents an analogous approach against a broad, long range goal. If the Foundation is established as proposed, it could serve as the vehicle to organize such task force efforts in areas within the scope of its mission. However, organization of such task forces in areas of current agricultural products should be undertaken by establishment of specific groups organized by producer associations, such as the national Corn Growers Association, with cooperation of relevant USDA agencies (i.e., in marketing and/or research areas).

Evolution of the New Farm and Forest Products Task Force


Agricultural and forestry needs, challenges and oppportunities
Secretary of agriculture challenge forum
Oct '84
Formation of new farm and forest products task force
June '85
Report on conclusions recommendations proposals
June '87
National priority: diversification of agriculture and forestry
National goal: 150 acres of new product demand by 2012
Establishment of foundation for new farm and forest products
Establishment of trust fund for foundation
(1987?)

IN CONCLUSION . . .

The New Farm and Forest Products Task Force recognizes that the recommendations and proposals presented above merely represent starting points for a needed and concerted national effort. The objective is to revitalize all sectors of U.S. agriculture through diversification, and thereby realize the full productive contribution that agriculture and forestry can make to the national economy.

There are, of course, no panaceas for the myriad of challenges facing agriculture and forestry, let alone the entire Nation. Nonetheless, the Task Force has a plausible vision of the agricultural and forestry industries of the future. The vision is one of dynamic, wholly revitalized industries - full of excitement, prosperity, and growth - and ones which are magnets for the country's best human resources.

The undertaking to move toward that vision through the diversification of agriculture is necessarily a long-term venture, and major results are not likely to be obtained before the end of the century. However, unless ideas, such as the ones suggested above, can somehow now be turned into action, the Nation is likely to be facing an agricultural and national crisis 30 years from now which is at least as grave as the one today.

As previously mentioned, exactly 30 years ago, the Task Group on New and Special Crops presented their findings and recommendations to the President's Appointed Bipartisan Commission on Increased Industrial Use of Agricultural Products. Their report makes very interesting reading, and much of what was said 30 years ago is essentially still true today. We members of today's Task Force sincerely hope that will not also be the case 30 years from now.

Relevant perspective comes from Mr. William G. Lesher, formerly an Assistant Secretary in the Department of Agriculture, who commented,

> "In this day, when everyone seems to be looking for new growth industries that the U.S. can become competitive in, such as high technology, it is ironic that we could lose the most efficient industry we have, which is agriculture, through our own doing."

Additional perspective relevant to the proposals above comes from Professor James T. Bonnen of Michigan State University who wrote:

> "Successful systems evolve in an iterative and interactive manner. They are not conceived or planned as a whole and then put into place. No one knows how to do that successfully. Scientific inquiry, policy, and institution building decisions are made under great uncertainty, with imperfect knowledge."

The New Farm and Forest Products Task Force believes that now is the time to begin the needed iterative and interactive process - if U.S. agriculture is to be fully revitalized to its maximum potential, and not lost as a cornerstone of American competitiveness and prosperity!

Appendix

Task Force Members and Sponsoring Organizations

Chairman:
Dr. Ronald L. Sampson
The Procter & Gamble Company

Mr. Edward Andersen
National Grange

Mr. Donald E. Anderson
The Andersons

Mr. Martin L. Andreas
Archer Daniels Midland

Dr. Terence W. Barrett
W. J. Schafer Associates, Inc.

Dr. Melvin G. Blase
Department of Agricultural Economics
University of Missouri

Dr. Chester T. Dickerson
Monsanto Corporation

Mr. Jeff Gain
National Corn Growers Association

Mr. Roger J. Gaire
Foster Wheeler USA Corporation

Mr. Allan D. Holiday
Farmland Industries, Inc.

Mr. Norman Johnson
Weyerhauser

Dr. Gary D. Jolliff
Department of Crop Science
Oregon State University
(Co-sponsored by the Council for
Agricultural Science and Technology)

Dr. Michael Ladisch
A. A. Potter Engineering Center
Purdue University

Dr. John Long
Archer Daniels Midland

Mr. Robert J. McCoy
The Procter & Gamble Company

Mr. Bobby F. McKown
Florida Citrus Mutual

Dr. D. Bruce Merrifield
U. S. Department of Commerce

Dr. Philip Nelson
Food Science Department
Purdue University

Dr. Donald E. Nelson
Extension Service
U. S. Department of Agriculture

Ms. Jane M. Ross
Grants & Program Systems
U. S. Department of Agriculture

Dr. Eldon W. Ross
Forest Service
U. S. Department of Agriculture

Mr. Mickey Stewart
ASCS Office
State of Nebraska

Dr. William F. Stoll
Technical College
University of Minnesota Technical
College, Waseca

Dr. Don Tilmon
Cooperative Extension Service
University of Delaware

Dr. John R. Welser
Upjohn Company

Dr. Charles P. West
Resin Research Laboratories, Inc.

Acknowledgements from the Task Force

The work of the New Farm and Forest Products Task Force was made possible through the dedicated efforts and generous support of many individuals and organizations. The voluntary effort of each member, and the support of each member's sponsoring organization, enabled the work to progress without a budget or direct funding support. Because of the unusual circumstances involved, the Chairman particularly wishes to express his appreciation to the Procter & Gamble Company for their support of his efforts.

Although encouraged and supported by the U.S. Department of Agriculture, the Task Force was an independent body. Consequently, the group's conclusions and recommendations do not necessarily reflect the views of that Department. Nonetheless, the work of the Task Force could not have been accomplished without the coordination and support of the Department of Agriculture, especially the Office of the Secretary, the Office of the Assistant Secretary for Science and Education, and the Office of Critical Materials. In addition, the counsel and perspectives provided by Dr. Orville G. Bentley, Assistant Secretary for Science and Education, and the Department members of the Task Force Secretariat listed below, were constructive, helpful, and much appreciated.

Similarly, although the findings of the Task Force do not necessarily reflect the views of any particular outside contributor to its work, the individuals listed below as Task Force Associates must be acknowledged. Although not a member of the Task Force, each Associate made substantive contributions to their work. The perspectives the Associates shared, and the time and effort they contributed, were much valued and appreciated.

Task Force Secretariat

(Note: The Secretariat was formed to provide liaison between the Task Force and the Department of Agriculture. With the exception of the Task Force Chairman, each member of the Secretariat was affiliated with the Department.)

Dr. Andrew Cowan
Agricultural Research Service

Mr. Michael Hoback
Science and Education

Mr. Joseph H. Howard
National Agricultural Library

Dr. Vivan Jennings
Extension Service

Dr. David B. Johnson
Forest Service

Mr. Robert W. Long
Science and Education

Dr. Paul F. O'Connell
Grants & Program Systems

Ms. Jane M. Ross
Grants & Program Systems

Dr. Charles B. Rumburg
Cooperative State Research

Dr. Ronald L. Sampson
Task Force Chairman

Mr. Howard C. Tankersley
Soil Conservation Service

Dr. Richard Wheaton
Office of Critical Materials

Task Force Associates

Mr. Dennis Avery
Bureau of Intelligence and Research
U. S. Department of State

Dr. L. James Butler
Department of Agricultural Economics
University of Wisconsin

Dr. T. Austin Campbell
Agricultural Research Service
U. S. Department of Agriculture

Hon. S. Mason Carbaugh
Department of Agriculture and
Consumer Services
State of Virginia

Mr. Stan Cath
Agricultural Research Institute

Ms. Melinda Cohen
National Association of State Foresters

Mr. John C. Datt
American Farm Bureau Federation

Mr. Julian J. Doyle
SIROTECH Limited

Dr. James Duke
Agricultural Research Service
U. S. Department of Agriculture

Mr. Michael Edwards
Department of Agriculture
State of New York

Mr. David M. Goodman
New Jersey Commission on
Science and Technology

Mr. Ralph E. Grossi
American Farmland Trust

Dr. Richard Hahn
A. E. Staley Manufacturing Company
(Industrial Research Institute)

Mr. Vern F. Highley
Agricultural Consultancy

Dr. Donald A. Holt
Agricultural Experiment Station
University of Illinois

Dr. Lee Kolmer
Agricultural Experiment Station
Iowa State University

Dr. E. Charles Leonard
Humko Chemical Division
WITCO Corporation

Dr. William G. Lesher
Lesher & Associates

Dr. James A. Patterson
Ohio Farm Bureau Federation

Mr. Roger Salquist
Calgene, Inc.

Dr. Howard A. Schneiderman
Monsanto Corporation

Mr. Hal Smedley
National Corn Growers Association

Dr. Dale Stansbury
National Resources and
Environment Office
National Association of
State Universities and
Land Grant Colleges

Mr. Gerald T. Underwood
U. S. Department of Commerce

Dr. Dorothy VanZandt
University of Maryland

Dr. Joe Varner
Biology Department
Washington University

Dr. Noel Vietmeyer
National Academy of Sciences

A Bill

To establish a Foundation for New Farm and Forest Products.

Draft Legislation

Be it enacted by the Senate and the House of Representatives of the United States of America in Congress assembled, that this Act may be cited as the "Foundation for New Farm and Forest Products Act of 1987".

Findings

SEC. 2. The Congress finds and declares that—

(a) the agricultural products industry, the largest contributor to foreign export trade, is confronting strong competition in world markets;

(b) emerging and developing nations are increasingly taking advantage of inexpensive labor and modern technology to produce crops far in excess of their needs, while other developed nations are increasing their agricultural productivity which in turn reduces their import requirement and/or increases their export surplus to compete with U.S. agricultural exports; and

(c) as a result of the above, utilization of U.S. agricultural exports are shrinking, resulting in diminished demand, lower commodity prices, and lower profitability throughout agriculturally-related industries, causing significant losses to the United States economy.

Purpose

SEC. 3. It is the purpose of this Act through the Foundation established under section 5—

(a) to mobilize private sector initiatives to capitalize on advanced technology unique to the United States and suitable for use by the agricultural and forestry industries.

(b) to identify and develop through cooperative efforts between industry, universities and government laboratories industrial products needed to diversify markets for agricultural and forestry products; and

(c) to promote shared risks, accelerated development time and pooling of skills which will be necessary to strengthen the agricultural and forestry industries.

Definitions

SEC. 4. As used in this Act—

(a) the term "Foundation" means the Foundation for New Farm and Forest Products established by section 5;

(b) the term "Secretary" means the Secretary of Agriculture;

(c) the term "Director" means the Director of the Foundation of New Farm and Forest Products, as provided for in section 5 (b) (2);

(d) The term "Board" means the New Farm and Forest Products Board as provided for in section 5 (b) (1); and

(e) the term "Fund" means the New Farm and Forest Products Fund, as provided for in section 11.

Establishment

SEC. 5. (a) There is hereby established in the executive branch of the Federal Government a Foundation for New Farm and Forest Products.

(b) There are hereby established in the Foundation—

(1) a New Farm and Forest Products Board, to function in accordance with section 7; and

(2) an Office of the Director of the Foundation, to function in accordance with section 8.

(c) The Foundation shall be located at a site within the United States to be determined by the Secretary, and shall be administered in accordance with existing Federal laws.

(d) In addition to the Director, the Foundation shall have such other officers and employees as the Board may determine to be necessary or appropriate.

Functions of the Foundation

SEC. 6. The Foundation is authorized and directed—

(a) to search out potential agriculture-based industrial products and processes;

(b) to quantify the economic and technical parameters that must be met for commercial viability for any products or processes so identified by the Foundation;

(c) to encourage and participate in cooperative programs; to facilitate the transfer of market relevant technologies from government laboratories to industry; to seek to capitalize on advanced technology; to develop proprietary agriculture-based industrial products and processes that will both expand and diversify agriculture in the United States; and

(d) to further assist the formation of cooperative programs by entering into grants and cooperative agreements with other interested parties.

New Farm and Forest Products Board

SEC. 7. (a) The Foundation shall be operated under the general supervision and policy control of a New Farm and Forest Products Board, which shall consist of nine members, eigth appointed by the Secretary, plus the Director.

(b) of the persons appointed by the Secretary to the Board—

(1) one shall be from the Department of Agriculture;

(2) one shall be from the Department of Commerce;

(3) one shall be from the National Academy of Sciences;

(4) one shall be from the membership of the Agricultural Research Institute;

(5) one shall be from the membership of the Industrial Research Institute;

(6) one shall be from farm/producer associations, beginning with the National Corn Growers Association; and

(7) two shall be from private sector companies representative of industrial materials industries in the United States.

(c) The Secretary shall designate one member of the Board as chairperson and one member as vice-chairperson for a term of office not to exceed three years. The vice-chairperson shall perform the duties of the chairperson in the latter's absence. In case a vacancy occurs in the chairpersonship or vice-chairpersonship, the Board shall elect a member to fill such a vacancy.

(d) The term of office of each member of the Board shall be three years, except that (1) any member appointed to fill a vacancy occuring prior to the expiration of the term for which his predecessor was appointed shall be appointed for the remainder of such a term; and (2) the terms of office of the three members first taking office under subsection (b)(2) shall expire, as designated at the time of their appointment, one at the end of one year, one at the end of two years, and one at the end of three years. No member shall be eligible to serve in excess of two consecutive terms.

(e) The Board shall meet at least once every three months at the call of the chairperson, or upon the written request of two of the members. A majority of the voting members of the Board shall constitute a quorum.

(f) Members of the Board appointed from the private sector under subsection (b)(2) may receive compensation when engaged in the business of the Foundation at a rate fixed by the chairperson but not exceeding the daily equivalent of the rate provided for level GS-18 of the General Schedule under section 5332 of title 5, United States Code, and shall be allowed travel expenses as authorized by section 5703 of title 5, United States Code. Members who receive such payment shall not be considered employees of the United States.

(g) The Board shall, in addition to any powers and functions otherwise granted to it by this Act—

(1) establish the policies of the Foundation, in accordance with applicable policies established by the President and the Congress;

(2) review the budget of the Foundation;

(3) review the programs of the Foundation;

(4) establish committees and procedures to approve or disapprove every grant, contract, or other funding arrangement the Foundation proposes to make, except that a grant, contract, or other funding arrangement involving a commitment of less than $200,000 may be made by the Director without specific Board action, if the Board has previously reviewed and approved the program of which that commitment is a part.

(h) The Board is authorized to appoint a staff consisting of professional staff members and such clerical staff members as may be necessary. The professional staff members may be appointed without regard to the provisions of title 5, United States Code, governing appointments in the competitive service and the provisions of chapter 51 of such title relating to classification, and may be compensated at a rate not to exceed the rate provided for level GS-18 of the General Schedule under section 5332 of such title.

(i) The Board is authorized to establish such special commissions and contributing memberships as it may from time to time deem necessary for the purposes of this Act.

(j) Board members shall be appointed not later than ninety days after the date of the enactment of this Act.

Director of the Foundation

SEC. 8. (a) The Director of the Foundation shall be appointed by the Board, and approved by the Secretary. The Director shall receive basic pay at the rate provided for level II of the Executive Schedule under section 5313 of title 5, United States Code, and shall serve for a term of five years unless removed by the Board.

(b) Except as otherwise specifically provided in this Act the Director shall exercise all of the authority granted to the Foundation by this Act.

(c) The Director may make such provisions as he deems appropriate authorizing the performance of any other office, agency, or employee of the Foundation of any of his functions under this Act.

(d) The Director shall formulate the programs and budgets of the Foundation, in consultation with the Board. As a basis for the selection and conduct of the Foundation's programs, the Director shall prepare, for the approval of the

Board, a short-range plan of activities and a long-range plan of activities. Each plan shall as fully as possible prioritize the full range of research activities appropriate to the Foundation. Such plans shall be prepared within one year after the initial selection of the Director, and each such plan shall be updated annually.

General Authority of the Foundation

SEC. 9. (a) The Foundation shall have the authority, within the limits of available appropriations, to do all things necessary to carry out the provisions of this Act, including but not limited to the authority—

(1) to establish additional offices and other organizational structures within the Foundation;

(2) to prescribe such rules and regulations as it deems necessary governing the manner of its operations and its organization and personnel;

(3) to make such expeditions as may be necessary for administering the provisions of this Act;

(4) to enter into grants, contracts, cooperative agreements, or other arrangements with whatever persons, organizations, countries, or other entities are deemed most useful by the Foundation to accomplish the purpose of this Act. Preference in such grants shall be given to proposals which are cooperatively funded by industry. Information received by the Foundation incident to this subsection shall be exempt from disclosure under section 552 of title 5, United States Code, and shall not be made publically available except in a judicial or administrative proceeding in which such information and material is subject to any protective order;

(5) to require as a condition of any grant or cooperative agreement to which the Foundation is a party that any projects funded in whole or part by the Foundation shall pay an agreed upon royalty on sales to the Foundation;

(6) to acquire, hold, or sell real and personal property of all kinds necessary to carry out the purpose of this Act;

(7) to receive and use funds and property donated by others, if such finds and property may be used in furtherance of the purpose of this Act. For the purpose of Federal income, estate and gift taxes, such donations shall be considered as a gift or bequest for the use of the United States;

(8) to accept and utilize the services of voluntary and uncompensated personnel, and provide transportation and subsistence as authorized by section 5703 of title 5, United States Code, for persons serving without compensation;

(9) to arrange with and reimburse other Federal agencies for any activity which the Foundation is authorized to conduct;

(10) to receive funds from other Federal agencies for any activity which the Foundation or any such other agency is authorized to conduct; and

(11) to appoint and fix the compensation of personnel necessary to carry out the provisions of this Act.

(b) Except as provided otherwise in this Act, appointments under subsection (a)(11) shall be made in accordance with the provisions of chapter 51 and subchapter III of chapter 53 of title 5, United States Code; but the Director may, in accordance with such policies as the Board shall prescribe, employ technical and professional personnel and fix their compensation, without regard to such provisions, as he deems necessary to carry out the purpose of this Act.

Annual Reporting

SEC. 10. The Director of the Foundation shall issue an annual report to the Secretary, detailing activities of the Foundation, including staff changes, status, and operational costs, together with an accounting of program allocations and project activity including the current status of each project.

New Farm and Forest Products Fund

SEC. 11. (a)(1) There is established in the Treasury of the United States the New Farm and Forest Products Fund. The fund shall be available to the Director, without fiscal year limitation, for use as a revolving fund to carry out activities of the Foundation.

(b) There shall be deposited in the fund—

(1) Interest earned by money invested by the Secretary in long-term securities;

(2) Payments received from any source for products, services or property furnished in connection with Foundation activities.

(3) Royalties earned by the Foundation from successfully commercialized products funded in whole or part by grants or cooperative agreements executed by the Foundation.

(4) Donations accepted by the Director on behalf of the Foundation, as provided for in section 9(a)(7).

Authorization of Appropriations; Related Matters

SEC. 12. (a) **Authorization of Appropriations.**—To carry out this act, there is authorized to be appropriated to the Secretary $200,000,000 in fiscal year 1988, and each of the four fiscal years thereafter. The appropriations are to be obtained from the proceeds of the sale of various commodities held by the Commodity Credit Corporation each year during the five year period, and to be invested in long-term securities of the United States Government. Interest earned from these investments shall be paid into the fund.

Availability of Appropriated Funds.—After twenty years the money authorized under subsection (a) shall revert to the Treasury of the United States unless extended by the Congress.

Limitations on Expenditure.—Not more than 5 percent of the interest income paid into the fund in a fiscal year may be expended for administrative expenses incurred to carry out this Act.

Senator CONRAD. Well, let me first of all, once again thank you for the presentation of this report. It is my intention that we will go to the other members of your task force, and then we will have a chance to pursue questions. I have many I would like to ask.

So let's proceed with Jeff Gain, the chief executive officer of the National Corn Growers Association.

STATEMENT OF JEFFREY W. GAIN, CHIEF EXECUTIVE OFFICER, NATIONAL CORN GROWERS ASSOCIATION [NCGA]

Mr. GAIN. Thank you, Mr. Chairman.

It is nice to be here to have an opportunity to talk about some forward thinking ideas instead of concern about target prices and loan levels, and 5½ billion bushels of carryover problems and CCC funding and all those kinds of issues.

The National Corn Growers Association represents over 16,000 members in 47 States and over 630,000 corn farmers who invest a portion of their corn income to try to improve the profitability of the corn farmer and the corn industry. We are a nonprofit, nonpartisan organization working to expand the use, marketing and efficient production of corn.

My purpose here today, in addition to supporting in a very strong manner the results of our task force efforts, is to share the NCGA perspective of the future for the corn industry and to indicate to you our strong support of the concept of finding alternative uses for our abundant, renewable resources in agriculture, and corn in particular.

As you know, corn plays a very significant role in the U.S. and world economy, the agricultural industry, so I will not dwell on that aspect. What I would like to emphasize is the fact that corn and many other agricultural crops have great potential, particularly in nonfood uses.

In September 1984, the NCGA set forth on a rather unique and exciting journey into the future to explore potential new uses, particularly nonfood uses for corn. We commissioned a special report by Kelly Harrison Associates, Inc. and I have submitted a copy of that for the record, to identify potential new corn uses. We also have just concluded the first annual National Corn Utilization Conference, which was held June 11 and 12 in St. Louis, Missouri. We were extremely pleased with the response of over 250 persons in attendance. The breakout sessions that we held were in three areas: ethanol, materials and biodegradables, and chemical feedstocks.

As you might guess, the first time you do something like this, you are quite apprehensive. You hold the party and nobody came——

Senator CONRAD. I've had parties like that.

Mr. GAIN. So have I. [Laughter.]

Senator CONRAD. Fundraising efforts.

Mr. GAIN. We were very pleased with this.

Almost without exception, conference participants were enthusiastic about the opportunity to gather under this banner of new uses to discuss where we are, where we should be heading, what we know, and I think most importantly of all—what we do not know and we need to find out to move forward.

Much of what private industry people do, producers in particular, is not known to us in the public sector. It is difficult in a conference like this to get them to share ideas about what their problems are. But our hope is that by getting people together with common concerns, we can identify where the brick walls are that they run into.

These get into the basic areas that I think in a public fashion we can address. What are the basic problems of starch conversion and chemistry that everybody has an interest in, regardless of whether you're going to make a widget or a new baby diaper out of it. That was really our interest here in pulling people together.

Attendees encouraged us to make this an annual conference; and we do plan to do so. Perhaps in the future we will hold more specialized conferences to explore specific areas of potential. This is more of a general approach, but I think you can take a look at the biodegradable plastics in detail, for example; and what can we do jointly here to move that forward.

We are hopeful that, after a thorough analysis of the conference proceedings, what we can come up with, as far as corn growers are concerned, would be what I refer to as a "Manhattan Project" for corn utilization. A plan that will identify the many specific areas of need to help put new products from corn on the market, and to develop an overall, long term plan and approach to that.

That plan obviously, and that approach, would tie into a utilization foundation of this kind, hopefully, with specific ideas and recommendations that were needed to move forward in certain areas.

Several very interesting and also very troublesome points have surfaced in the process that we started nearly 3 years ago.

One, that precious little basic utilization research is being done in the new nonfood uses area using corn or other agricultural products. I think we skimmed the surface of that this morning.

Second, that a significant number of potentially viable new uses have been discovered over the past 30 to 40 years. They are simply sitting on the shelf gathering dust, and that should be of concern to us.

Three, that we are not training carbohydrate chemists in sufficient numbers today to be able to pursue new market opportunities. In talking with the people at the conference that we held a couple of weeks ago, that was one of the primary concerns. Where do we get the technical expertise to do what it is we are setting out to do here? I submit to you that is a long term problem. It takes Dr. Bentley 7 to 10 years to train a good scientist, and then he needs to have some experience besides.

So those are some areas that are of great concern to us. There is also another concern. This concern is addressed in the report of the Farm and Forest Products Task Force being presented to you today by the Secretary of Agriculture.

The concern addressed is really quite simple: If we are to make a major effort to identify potential new uses of existing crops and to help establish new crops which can provide new nonfood products get established, then a bold new structure with adequate resources needs to be established to concentrate on these needs. The task force feels that we have, in fact, prepared a recommendation which allows us to do just that. While the structure can, no doubt, be refined and improved, the basic concept is valid and can make a real contribution not only to U.S. agriculture, but to our total economy, our environment, and, as has been indicated, even our national security. I think that is an underlying concern that all of us have.

There are many specific examples of potential new uses which I have attached to my prepared statement today to which you might refer to later.[1] Some of them apply, I think quite well, in North Dakota in terms of uses as well as in many other areas. Let me just list a few: One, as Dr. Bentley alluded to, is the expanded use of ethanol in our fuels—we have seen it, in fact in the Denver experiment that is going on, their final decisions are being, I think, promulgated this week—to clean up the air pollution problems we face; two desulfurization of coal, which can also reduce air pollution, has a lot of other really good advantages. Illinois again is looking at a pilot plant in this field; an example of where some funding is needed to find out, as Dr. O'Connell was saying here, about the actual processes that we need to try to see if they will work. Three, the use of calcium magnesium acetate instead of salt to de-ice highways has a lot of advantages. It reduces the contamination of water and underground utilities. I understand in New York City alone, for example, the cost of salt contamination to underground utilities on an annual basis is $75 million. It corrodes concrete. As one of my staff members says, it rusts out bridges and Buicks—salt on the highways. If we can eliminate those kinds of adverse impacts on our environment through the use of some of these renewable resources that we have, I think there are many economic as well as social advantages.

Four, the use of biodegradable materials has been talked about here, from lactic acid and starch in making fast food packaging, blow molded bottles, adhesives, and many other materials.

Five, the transformation of zein—from corn—into a textile fiber which was produced very successfully in the late 1940's and 1950's was dropped. There is a product that was on the shelf. I understand from one of the members of our task force that the Department of Defense has even written specifications using this material, and would like to use it again, but nobody's making it. It has some very desirable characteristics. This kind of a product needs to be dusted off and put back in the mix of things.

Senator CONRAD. Do you know why it was——

Mr. GAIN. Well, just bits and pieces. I think part of it was the synthetics that came out at that time, that replaced part of that market. I think there were some environmental and public health concerns about the use of formaldehyde in the process; and I understand that problem has been taken care of. I think now we are looking at a whole new set of economics in terms of the cost of synthetics and some of the other benefits that we want from the materials.

So as I think Dr. Bentley indicated, economics change, conditions change, and we need to have a process here to continually evaluate these products that we discover in Peoria at the regional lab and various other places, and find where there's a fit, and maybe give 'em a little shot in the arm to get started.

---

[1] Material is retained in the subcommittee file.

Last, I think reference was made to super slurper. That is one that is fun to look at; I do not know if you have seen the example where you take just a little powder in a glass like this and fill the glass with water, and then you turn it upside down and there is just a glob in there. Super slurper, which is a corn starch polymer that can absorb over 1,000 times its own weight in water and can be used for fuel filters, for example, on farms, baby diapers, soils, and no doubt many other uses.

A farmer, for example, in central Illinois and his father built a rather sizable industry. They supply a high percentage of all the fuel filters in the United States and a tremendous part of the export markets using this product. It was a group of farmers that invented the use of this product, taking it from the lab in Peoria. They got a lot of assistance from the people there as well.

What else is out there? We are not sure, but we are sure that we need to start looking in a very serious manner. We are already late in getting started. The corn growers and other growers can play a key role in grassroots support and have an extremely high interest in this discussion here today. It is a positive, forward-looking thing. It is something that we can do to help ourselves, and it is time we get started.

I think growers can provide a lot of support to you, Senator Conrad, and others, in looking at the opportunities that are out here. The Government can play a key role in establishing a well funded—and more importantly—high priority mechanism to pursue these new concepts and products. We're talking public policy here. I think that needs to be seriously addressed by the subcommittee and the Congress in total as a priority for not just U.S. agriculture, but for the United States, because we have a very valuable renewable resource here.

Then as you have seen from the discussion we have had, we are working with industry. This is a critical part of this if this is to work. The industry working with growers and with the Government, I think, can make it happen. We all have a key role to play.

I would like to conclude with a couple of things. One, this is not a final report today, in my estimation, and I think we have all alluded to that. It is a new beginning. This topic that is as old as civilization, really. A major effort was made in the 1930's; a regional lab was built and then, as has been indicated, we got to the point where we felt we couldn't produce enough corn, so to heck with anything else, we'll just grow it and grind it and feed it to hogs and walk it off the farm, or however you want to use it, because we can't grow enough anyway. Well, we know that's not true.

We know that if we are going to be smart about where we are going long term in agriculture, we will address these in a program that has continuity and longevity, because research is not something that you turn on and off, like a faucet. It is something that has to be ongoing, I think, to be effective.

Funding? Well, sure, we have got the concerns of Gramm-Rudman and all the other budget matters that I know you all are dealing with, but I think the mechanism that we are suggesting here is doable. We know how the CCC stocks are handled and we think that if you could sell a little bit of corn, a little bit of beans, maybe some wheat, some peanut butter and dairy products or whatever, and trickle that money back into this instead of back into the general revenues, which are unaccounted for basically, that is an easy, painless way to do it—$1 billion, $200 million over 5 years is loose change. Round those numbers off in the Federal budget and I think it is a doable thing that you need to take a hard look at.

We do not need to be discussing ways to manage our production. Those are very frustrating to all of us. North Dakota has a genuine problem. There is concern for agriculture and what you can do to stimulate it. It is the same for Illinois or Iowa or Missouri, and all the 50 States. This is a way we can work to utilize the capacity, the capability, the knowledge and the tremendous ability we have through biotechnology and all the other facets of scientific research that apply to this, to develop an aggressive future for U.S. agriculture and the U.S. economy.

So with that I simply want to say thanks for the opportunity to appear before you today, and I would be happy to respond to any questions you might have.

Senator CONRAD. Thank you very much for your testimony. Again, we want to thank you for your efforts as part of the task force. Before we go to questions, we will go to the final witness on this panel, Dr. Gary Jolliff, Professor of Crop Sciences at Oregon State University.

Again, your complete statement will be entered into the record. However you choose to present your testimony is fine.

Mr. JOLLIFF. Thank you, Mr. Chairman.

Senator CONRAD. I also want to welcome my colleague, Senator Karnes from Nebraska, who is on this subcommittee. We are proceeding here, Senator Karnes, hearing the testimony of this panel, and then we are going to open it up for questions.

Proceed.

STATEMENT OF DR. GARY D. JOLLIFF, PROFESSOR OF CROP SCIENCE, OREGON STATE UNIVERSITY, AND MEMBER, NEW FARM AND FOREST PRODUCTS TASK FORCE

Dr. JOLLIFF. Thank you, Mr. Chairman. It is a pleasure to be here, and I think after hearing these testimonies, you can see it has been a joy to work with this task force on behalf of the Nation.

I did make some revisions in my prepared statement, concerning my experience with the promotion of meadow foam, based upon the input that the task force had yesterday from some of your staff; so it is a bit different and I will let them be so advised.

Mr. Chairman and subcommittee members, my name is Gary Jolliff. It is truly a pleasure to be here before you today as an employee of a land-grant university. I am the only crop scientist who served on the New Farm and Forest Products Task Force. The Council on Agricultural Science and Technology, known as CAST, asked me to serve also as their representative on the New Farm and Forest Products Task Force. I served on their task force which responded to a request from the Joint Economic Committee of Congress for information on new agricultural crops. The response to Congress was made in CAST Report No. 102, entitled "New Crop Development: Needs, Procedures, Strategies, and Options" which was presented in hearings in October 1983.

For approximately 4 years I have been closely involved with the practical, historical, and policy issues related to development of new crops.

My remarks will focus on summarizing the conclusions I have made from this experience and research. It is contained in two draft manuscripts submitted for the record of today's hearings. These manuscripts have had substantial review, but nevertheless, are my perspective, and do not represent an official view of either Oregon State University or the Council for Agricultural Science and Technology.

The majority of my remarks will now focus on summarizing the written testimony submitted. The first is a prepublication manuscript entitled "New Crops and Products from American Agriculture: Rationale for Institutional Change and Strategic Planning." This paper demonstrates that public funding of research and development of new crops has been inadequate in amount and timing to achieve the needed results.

Research, as Dr. O'Connell mentioned, and I emphasize, plays a key role of increasing crop yields to make them be economically competitive. Yet we want to try to see whether new crops are going to be economically competitive before we invest in the research to increase the yield. It is a vicious circle, a chicken and egg situation.

This manuscript describes why an institutional change is necessary to serve the needs of American agriculture. That institutional change must include the establishment of a forceful, enduring, and accountable voice for new crop development to facilitate necessary long-term high-risk multidisciplinary research and development and commercialization. Such an effort will require vigorous leadership, innovative policies, and tough management.

The New Farm and Forest Product Task Force report addresses this most fundamental watershed issue. History proves that entities without political representation typically do not receive attention. New crops, almost by definition, do not have political representation. Perhaps it has been unrealistic to expect the USDA to be a sufficiently firm and persistent voice for new crops when large numbers of special interest groups keep the USDA occupied and accountable for what they consider to be equitable distribution of scarce research funds.

Past development efforts on new crops have been initiated with high expectations, and low support levels and duration. The result has been fairly consistent disappointment and disillusionment. It begs the typical response of "I told you so," from those who were not in favor of such investments at the outset. It is very easy for negative attitudes in new crop development to become self-fulfilling prophecies.

Very few persons have had experience domesticating and commercializing a wild plant. Therefore, it is difficult to gain the political support needed to fund such projects for the long haul. This is true even among crop scientists. Even plant breeders will describe the marvelous improvements which can be made in plants through genetics, breeding, and biotechnology; that is, at least for the familiar plants. Those visions and innovations soon fade when the topic is changed to unfamiliar new crops. Thus there is a need for an extension of the "can-do" attitude and mindset from the familiar to the unfamiliar crops.

Most of us would like instant solutions; that makes accountability a nice, easy, tidy process, but crop development does not work that way. It was more than 200 years from the time the soybean was first brought to North America until it became one of our most significant crops. Now we marvel at this prodigious plant, but a short 50 years ago there was a struggle for a political voice for soybeans.

A second manuscript has been submitted for the record. It is entitled, "New Crop Development: Opportunity and Challenges." Attached to the prepared statement, and I would draw your attention to it now, is the first exhibit, a map of the eastern half of the United States which illustrates the adaptation and distribution pattern for soybean acreage growth in the United States from 1920 through 1985.

That acreage expansion was based on plant breeding and variety of development. The growth radiates from centers having plant breeders with access to useful plant germplasm, provided by the USDA, by the way. Such crop development has been common with most major crops, yet the needs for similar breeding of new crops have had meager attention compared to what we know it takes to get the needed results. The same story can be told for the need to develop plant germplasm for new crops. New crops simply have not been given much of a chance for development.

It was emphasized by your staff that responses to invitations to participate in these hearings in consideration of legislative action for the development of new crops and products typically included the request for an example of a new crop or product.

Therefore, at the risk of being perceived as biased, I offer you an illustration of a model situation that fits the spirit of Senate bill 970, testimony by Senator Harkin as recorded in the April 9, 1987, Congressional Record, pages S9444–S9448.

[This material is retained in the committee file.]

Mr. JOLLIFF. I beg your indulgence, as I use a rather personal illustration of what can be done. In less than 20 years at Oregon State University, a wildflower native to the Pacific Coast area has been domesticated and commercialized as a new source of industrial oil.

The short timeframe for this achievement may be a record. Few persons have seen such a development within their lifetime; therefore, it is not surprising that this type of concept is foreign to even farmers and scientists. The effort has been supported primarily at the State level on a shoestring budget.

You will be interested to know that it was accomplished without using the new tools of biotechnology. That is why I believe it is a mistake to decide or to dictate in Senate bill 970 that at least 50 percent of the funds be spent on biotechnology. I would emphasize also that this crop probably can be accelerated in this development by the appropriate use of biotechnology, but I don't think it's appropriate to box ourselves in that manner of terminology.

It is important to note that the uniqueness of the oil in the nut of this plant was discovered by USDA scientists, as alluded to earlier by Dr. Bentley, nearly 30 years ago. They were searching for alternatives to surplus crops. However, the USDA organizational structure had no provision for developing the plant into a viable economic crop for farmers, and the budget which was used at that time to discover and characterize the unique products in the oil soon were redirected away from new crops to fund work on the major commodities.

This illustrates the types of gaps which have blocked and continue to block technology transfer. This new crop presently needs a supportive entity and voice for new crops such as the proposed Foundation for New Farm and Forest Products to launch it as a vigorous producer of wealth for agriculture and U.S. industry.

I have with me a proposal which illustrates that State and private funding in Oregon are in a position to form a Federal partnership. This is a current example of a critical need for the kinds of organizational capabilities previously described by both Dr. Sampson and Mr. Gain, and detailed in the New Farm and Forest Products Task Force report.

Incidentally, the name of the crop is meadowfoam; and if the news media is interested, they can see it being harvested in Oregon for a few more days yet this year.

I also have copies of letters from industrial firms estimating the market size for the oil at certain oil prices. I would be pleased to provide these letters for the subcommittee.

[Copies of letters from industrial firms are retained in the subcommittee file.]

Dr. JOLLIFF. Now I will return to the text as previously prepared.

I will conclude my remarks with a reference to a research investment model included in the second submitted paper, which is the second exhibit attached to your copy of the prepared testimony. It is included in both of the manuscripts mentioned above. Please refer to it in the prepared testimony at this time.

It represents the resources needed during the course of new crop development. The model is general, in that the values are relative in both amount and source. The solid lines represent the proposed funding profile through time. The discovery and domestication of potential crop plants is a highly risky proposition and not attractive to private industry or to very many land-grant universities and State agricultural experiment stations. Funding of that segment is clearly a USDA responsibility.

When potential agricultural utility is identified in the plant domestication process, State agricultural experiment station resources become a significant portion of the partnership with USDA to begin improving the plant as a potential new crop, and that is what was done with meadowfoam. Profit potential remains unclear at this point, and private industry probably is not yet interested. With the identification of profit potential, the commercialization process begins and private industry accepts some research funding burden.

Upon launching full crop production, industry begins to finance an ever increasing portion of the research investment. Funding by the USDA and the State agricultural experiment stations is reduced as the resources are redirected to other high risk new crop development efforts.

Contrast the two lines labeled as USDA funding. Note the major difference between the solid line of the proposed model and the broken line which depicts historical trends. There are two major and I think vital consequences of the historical approach. I draw your attention to that. First, note the serious lack of funds at the stages labeled Improvement/Commercialization and Pre-Commercialization Development. This results in a technology transfer gap. We have the technology to improve the profitability of crop plants, but the plant remains too undeveloped to attract the private investors to do the job. Public funds are not adequate because the crop does not yet have sufficient economic clout to be politically influential.

Presently the commercialization effort is suffering because it is in this political hinterland. This illustrates why Senate bill 970 needs language to improve funding of the commercialization process.

The second serious consequence is the disparity of the two lines at the right margin. This means that a crop production system which has the developed technology, acreage, industry, and organization to accept major research funding responsibility is not doing so. Furthermore, in addition to not carrying as much as it could, and probably should, it is consuming scarce research resources that are needed elsewhere. The irony, as has been proven with the development of soybean, is that the new crop probably will help most all producers, even if they were not in favor of funding the research development at the outset.

Recent activity such as the first corn utilization conference sponsored by the National Corn Growers Association as described by Jeff Gain is evidence of a recognized responsibility by the commodities organizations for self help.

A very significant barrier to new crop development is the political inflexibility available to the USDA to redirect funds from major commodity research areas. We all acknowledge that the Federal budget for agriculture research is too small. But we also know that the potential for spending money on most topics is virtually endless. Therefore, since Congress must, and will, put a lid on expenditures, it follows that the commodity groups which have some capacity to help themselves should do so.

The needed resources for the development of the necessary new crops and products need to be under the control of an entity such as the proposed Foundation by the New Farm and Forest Products Task Force. The Foundation in particular, so as to avoid the continual political dilemma for resource allocation faced by the USDA.

Otherwise, it seems that the House and Senate Appropriations Committees would have to do the restructuring of present priorities in agricultural research.

I suggest that a Foundation for New Farm and Forest Products, for reasons described in Dr. Sampson's testimony would be the most credible way to prioritize the use of funds for development and commercialization of new farm and forest products.

I believe that the USDA has had the mandate, the authorization, the talent, and the resources to develop new crops for more than a century. There is a very limited track record of aggressive leadership and serious investment in new crop development; this needs upgrading. The economic consequences of chronic underfunding for research in new crops have been staggering. I believe that USDA has had some serious interest in new crops. But, for the reasons described above, I do not believe it is politically practical for USDA to achieve within a reasonable timeframe what U.S. agriculture desperately needs.

An entity, such as the proposed Foundation for New Farm and Forest Products, is needed. It could alleviate the resource reallocation problem from the outset, and the USDA could continue to have the opportunity to invest and cooperate with all the resources it could identify within its many existing programs.

Thank you for your kind attention, and I would be pleased to attempt to respond to questions.

[The prepared statements of Jeffrey W. Gain and Dr. Gary D. Jolliff, with attached material, follow:]

STATEMENT OF

JEFFREY W. GAIN
CHIEF EXECUTIVE OFFICER
NATIONAL CORN GROWERS ASSOCIATION

BEFORE

SUBCOMMITTEE ON AGRICULTURAL RESEARCH

AND GENERAL LEGISLATION

UNITED STATES SENATE

ON

JUNE 26, 1987

GOOD MORNING. I AM JEFFREY GAIN, CHIEF EXECUTIVE OFFICER OF THE NATIONAL CORN GROWERS ASSOCIATION (NCGA). WE REPRESENT OVER 16,000 MEMBERS IN 47 STATES AND OVER 630,000 CORN FARMERS WHO INVEST A PORTION OF THEIR CORN INCOME TO TRY TO IMPROVE THE PROFITABILITY OF THE CORN FARMER AND THE CORN INDUSTRY. WE ARE A NON-PROFIT, NON-PARTISAN ORGANIZATION WORKING TO EXPAND THE USE, MARKETING AND EFFICIENT PRODUCTION OF CORN.

MY PURPOSE HERE TODAY IS TO SHARE THE NCGA PERSPECTIVE OF THE FUTURE FOR THE CORN INDUSTRY AND TO INDICATE TO YOU OUR STRONG SUPPORT OF THE CONCEPT OF FINDING ALTERNATIVE USES

FOR OUR ABUNDANT, RENEWABLE RESOURCES IN AGRICULTURE, AND CORN IN PARTICULAR. I AM SURE YOU ARE ALL AWARE OF THE SIGNIFICANT ROLE THAT CORN PLAYS IN THE U.S. AND WORLD ECONOMY, SO I WILL NOT DWELL ON THAT ASPECT. WHAT I WOULD LIKE TO EMPHASIZE IS THE FACT THAT CORN AND MANY OTHER AGRICULTURAL CROPS HAVE GREAT POTENTIAL IN NON-FOOD USES.

IN SEPTEMBER OF 1984, THE NCGA SET FORTH ON A UNIQUE AND EXCITING JOURNEY INTO THE FUTURE TO EXPLORE POTENTIAL NEW NON-FOOD USES FOR CORN. WE COMMISSIONED A SPECIAL REPORT BY KELLY HARRISON ASSOCIATES, INC. TO IDENTIFY POTENTIAL NEW CORN USES. WE ALSO HAVE JUST CONCLUDED THE FIRST ANNUAL NATIONAL CORN UTILIZATION CONFERENCE HELD JUNE 11-12 IN ST. LOUIS, MISSOURI. WE WERE EXTREMELY PLEASED WITH THE RESPONSE OF OVER 250 PERSONS IN ATTENDANCE. BREAKOUT SESSIONS WERE HELD ON ETHANOL, MATERIALS AND BIODEGRADABLES AND CHEMICAL FEEDSTOCKS.

ALMOST WITHOUT EXCEPTION, CONFERENCE PARTICIPANTS WERE ENTHUSIASTIC ABOUT THE OPPORTUNITY TO GATHER UNDER THIS BANNER OF NEW USES TO DISCUSS WHERE WE ARE, WHERE WE SHOULD BE HEADING, WHAT WE KNOW, AND MOST IMPORTANTLY --- WHAT WE DO NOT KNOW AND NEED TO FIND OUT TO MOVE FORWARD. ATTENDEES

ENCOURAGED US TO MAKE THIS AN ANNUAL CONFERENCE AND PERHAPS EVEN HOLD MORE SPECIALIZED MEETINGS TO EXPLORE SPECIFIC AREAS OF POTENTIAL.

WE ARE HOPEFUL THAT, AFTER A THOROUGH ANALYSIS OF THE CONFERENCE PROCEEDINGS, WE WILL BE ABLE TO IDENTIFY A "MANHATTAN PROJECT" FOR CORN UTILIZATION. A PLAN THAT WILL IDENTIFY THE MANY SPECIFIC AREAS OF NEED TO HELP PUT NEW PRODUCTS FROM CORN ON THE MARKET.

SEVERAL VERY INTERESTING AND TROUBLESOME POINTS HAVE SURFACED IN THE PROCESS WE STARTED NEARLY THREE YEARS AGO: 1) THAT PRECIOUS LITTLE BASIC UTILIZATION RESEARCH IS BEING DONE IN THE NEW NON-FOOD USES AREA USING CORN OR OTHER AGRICULTURAL PRODUCTS; 2) THAT A SIGNIFICANT NUMBER OF POTENTIALLY VIABLE NEW USES HAVE BEEN DISCOVERED OVER THE PAST 30-40 YEARS AND ARE SIMPLY SITTING ON THE SHELF GATHERING DUST; AND 3) THAT WE ARE NOT TRAINING CARBOHYDRATE CHEMISTS IN SUFFICIENT NUMBERS TODAY TO BE ABLE TO PURSUE NEW MARKET OPPORTUNITIES.

THERE IS ALSO ANOTHER CONCERN. THIS CONCERN IS ADDRESSED IN THE REPORT OF THE FARM AND FOREST PRODUCTS TASK FORCE BEING PRESENTED TO YOU TODAY BY THE SECRETARY OF AGRICULTURE.

THE CONCERN ADDRESSED IS REALLY QUITE SIMPLE: IF WE ARE TO MAKE A MAJOR EFFORT TO IDENTIFY POTENTIAL NEW USES OF EXISTING CROPS AND TO HELP NEW CROPS WHICH CAN PROVIDE NEW NON-FOOD PRODUCTS GET ESTABLISHED, THEN A BOLD NEW STRUCTURE WITH ADEQUATE RESOURCES NEEDS TO BE ESTABLISHED TO CONCENTRATE ON THESE NEEDS. THE TASK FORCE FEELS THAT WE HAVE, IN FACT, PREPARED A RECOMMENDATION WHICH ALLOWS US TO DO JUST THAT. WHILE THE STRUCTURE CAN, NO DOUBT, BE REFINED AND IMPROVED, THE BASIC CONCEPT IS VALID AND CAN MAKE A REAL CONTRIBUTION NOT ONLY TO U.S. AGRICULTURE, BUT TO OUR TOTAL ECONOMY, OUR ENVIRONMENT AND EVEN OUR NATIONAL SECURITY.

THERE ARE MANY SPECIFIC EXAMPLES OF POTENTIAL NEW USES WHICH I HAVE ATTACHED TO MY BRIEF REMARKS TODAY TO WHICH YOU MIGHT REFER LATER.↓ LET ME JUST LIST A FEW: 1) EXPANDED USE OF ETHANOL IN OUR FUELS TO CLEAN UP THE AIR POLLUTION PROBLEMS WE FACE; 2) DE-SULFURIZATION OF COAL WHICH CAN ALSO REDUCE AIR POLLUTION; 3) THE USE OF CALCIUM MAGNESIUM ACETATE INSTEAD OF SALT TO DE-ICE HIGHWAYS TO REDUCE THE CONTAMINATION OF WATER AND UNDERGROUND UTILITIES AS WELL AS THE CORROSION OF CONCRETE, BRIDGES AND VEHICLES; 4) THE USE OF BIODEGRADABLE MATERIALS FROM LACTIC ACID AND STARCH IN MAKING FAST FOOD PACKAGING, BLOW MOLDED BOTTLES, ADHESIVES AND MANY OTHER MATERIALS; 5) THE TRANSFORMATION OF ZEIN (FROM CORN) INTO A TEXTILE FIBER PRODUCED VERY SUCCESSFULLY

↓ Material is retained in the subcommittee file.

IN THE LATE 40'S AND 50'S; 6) AND SUPER SLURPER WHICH IS A CORN STARCH POLYMER THAT CAN ABSORB OVER 1,000 TIMES ITS OWN WEIGHT IN WATER AND CAN BE USED FOR FUEL FILTERS, BABY DIAPERS, SOILS AND NO DOUBT MANY OTHER USES.

WHAT ELSE IS OUT THERE? WE AREN'T SURE. BUT WE ARE SURE THAT WE NEED TO START LOOKING. WE ARE ALREADY LATE IN GETTING STARTED. THE CORN GROWERS AND OTHER GROWERS CAN PLAY A KEY ROLE IN GRASS ROOTS SUPPORT. THE GOVERNMENT CAN PLAY A KEY ROLE IN ESTABLISHING A WELL FUNDED, HIGH PRIORITY MECHANISM TO PURSUE THESE NEW CONCEPTS AND PRODUCTS. THE INDUSTRY WORKING WITH GROWERS AND GOVERNMENT CAN MAKE IT HAPPEN. WE ALL HAVE A KEY ROLE TO PLAY.

THIS IS NOT A FINAL REPORT TODAY. IT IS MERELY A NEW BEGINNING ON AN ISSUE AS OLD AS CIVILIZATION. IT IS TIME WE PUT IT IN ITS PROPER PERSPECTIVE.

I APPRECIATE HAVING THIS OPPORTUNITY TO APPEAR BEFORE YOU TODAY AND I WILL ATTEMPT TO ANSWER ANY QUESTIONS THAT YOU MAY HAVE. THANK YOU.

CORN NEWS

• NATIONAL • CORN • GROWERS • ASSOCIATION •

World Headquarters
1000 Executive Parkway
Suite 224
St. Louis, MO 63141
(314) 275-9915

Washington Office
201 Massachusetts Ave., N.E.
Suite C-4
Washington, D.C. 20002
(202) 546-7611

FOR RELEASE: May 15, 1987

MEDIA CONTACTS:	Harold Cutler	919/756-7103
	Marion Hartman	513/393-2139
	Steve Wentworth	217/877-9691
	Dan Ragsdale/Hal Smedley	314/275-9915

Editor's Note: The following information is the fourth in a series of eight news releases on the First Annual National Corn Utilization Conference and potential news uses for corn.

Denver, Other Cities Consider Mandating Ethanol Fuels To Clean Air

ST. LOUIS.....A coalition of environmentalists, health professionals, businessmen and farmers in Denver are holding their breath until June 19. And it's not just because the air's dirty.

That's the day the Colorado Air Quality Control Commission (AQCC) will close public hearings and likely issue an oxygenated fuels mandate in a race to lower Denver's record carbon monoxide levels.

U.S. corn growers will share a sigh of relief if the AQCC does follow an earlier recommendation by its Task Force that all gasoline sold in Denver between November 1 and March 1 contain a minimum level of oxygen. That's because ethanol, an oxygenating fuel additive derived from corn, could gain up to a 10 percent share of the Mile High City's winter gasoline market.

-over-

Ethanol production, which a decade ago consumed less than four million bushels of corn a year, now uses over 300 million bushels a year. The National Corn Growers Association (NCGA) has assisted Coloradans by acquainting legislators and regulators with research ethanol's properties. In addition, NCGA tirelessly lobbies with the companies in an effort to dispel myths circulated about ethanol.

But the best may be yet to come. Denver's position as a frontrunner in the rush to meet a December 31, 1987 deadline set by the federal Clean Air Act has gained the attention of the national media and nearly a dozen other cities with non-attainment status.

"Arizona, Minnesota and New Mexico have indicated their interest in the benefits of the pending Colorado program," reports John Cabaniss, policy analyst in the Environmental Protection Agency's (EPA) Office of Mobile Sources in Washington. "California is looking at oxygenated fuels and everything else to clean up Los Angeles' air problems."

This "domino effect" is why most of the major oil companies have rolled out their biggest guns to shoot down the proposal during the past 12 months. "An oil company lobbyist told me he didn't care about the 3.2 million people in Colorado. He was worried about Los Angeles, New York City, Phoenix and Albuquerque. Now those are some markets," says Barbara Charnes, director of Coloradans for Clean Air.

Yet the oil companies' intense efforts to discredit ethanol did not convince the AQCC Task Force during technical hearings last year. "All the major oil companies, even those which don't market here, showed up

-more-

to speak against ethanol," says Patty Stulp, an ethanol broker and member of the Task Force. "But none of them had a positive contribution to make toward cleaning up our dirty air."

Denver's air problems reflect geographic and climatic anomalies. It sits on the front range of the Rockies which subjects it to "air inversions where cold air comes over the mountains, particularly at night, and traps warm air near the ground," explains Ted Hollman, Air Pollution Control Specialist with the Colorado Department of Health.

"Two and a half million of Colorado's three million plus people drive up and down the front range on two major thoroughfares," adds Stulp. That many cars in the thin, mile-high air add to the problem, Hollman says. "At this altitude cars run oxygen-starved, which increases their carbon monoxide emissions. And when the temperature is cold, the chokes are on and fuel in running rich, which makes for more carbon monoxide. That's why it's a particular problem in winter," he says.

The problem is so severe that Fortune 500 companies rate bad air an issue in moving to Denver, a survey by Charnes' group indicates.

One solution, Cabaniss explains, is to simply make the fuel "leaner" by adding oxygen. "Typical gas has less oxygen than is found in ethanol. By adding 10 percent ethanol, you can elevate the oxygen level to three and a half percent. That alone will reduce the potential for formation of carbon monoxide," he says. "It's nothing magic; more oxygen in, less carbon monoxide out."

-more-

Denver, Other Cities Consider Mandating Ethanol Fuels To Clean Air

4-4-4-4-4

Ethanol has a competitor in its role as a fuel oxygenator, MTBE, a petroleum refinery product. But an 11 percent MTBE blend adds only two percent oxygen, Hollman points out. A seeming favorite of oil companies, this alternative fuel did not receive expected oil company support. "Logistical difficulties mean they can't get 10 percent of the market here fast enough. They have threatened to put a little MTBE in all fuels coming into Colorado because a federal waiver would prevent ethanol blending, but they know they face a lawsuit over restraint of trade if they try it," Charnes says.

"It's been quite an effort," she reflects. "The oil companies were so sure of themselves. We'd go into a conference with 25 of them and only four of us, but we got `em! We have a strong and committed coalition. Many businessmen, environmentalists and health professionals moved to Colorado in the 1960s and 1970s. They escaped Eastern cities for the clean, Rocky Mountain air. They and native Coloradans are proud of their state and are willing to go a long way to keep it clean."

Stulp says the AQCC is not expected to endorse just ethanol in June, but rather to issue a broad oxygenated fuels mandate. "Ethanol won't be locked in, but it won't be locked out," she says. "It will get a substantial share of the market."

A mandate is not the occasion for disbanding the coalition, however, Charnes hastens to state. "Between June 19 and November 1 comes the most important period. We are preparing a major consumer education campaign. The oil companies have made people afraid of ethanol by blaming it for everything that goes wrong with cars. We have to counteract that fear with accurate information derived from experience in other states," she says

Denver, Other Cities Consider
Mandating Ethanol Fuels To Clean Air
5-5-5-5-5

The NCGA will continue its efforts to bring the best research on ethanol to the public at its National Corn Utilization Conference in St. Louis, June 11-12. The conference is co-sponsored by Funk Seeds International. Experts in ethanol will present and evaluate the latest applications of this corn-derived alcohol. As in Colorado, the interest of many sectors of society can be served simultaneously by expanding the uses of corn from feedstuff to industrial feedstock.

"Colorado may be first to mandate oxygenated fuels, but we're being watched. What follows will be a multi-state response," she concludes.

-30-

National Corn Utilization Conference
Release No. 4

CARBON MONOXIDE LEVELS IN NON-ATTAINMENT CITIES
(9 parts per million (ppm) allowed over an 8 hour period)

CITY	CARBON MONIXIDE (PPM)	DAYS OVER MAXIMUM OVER LAST 3 YEARS
New York, NY	16	112
Phoenix, AZ	20	85
Provo, UT	19	73
Denver, CO	24	59
Albuquerque, NM	17	57
Los Angeles, CA	27	52
Jersey City, NJ	14	43
Anchorage, AK	16	43
Medford, OR	16	43
Fairbanks, AK	17	40
Chicago, IL	13	34

Source: EPA

A SURVEY OF POTENTIAL NEW CORN USES

Kelly Harrison Associates, Inc.
August 1986

TABLE OF CONTENTS

Executive Summary

I. Introduction 1

II. Corn Markets: Past and Future 10

III. Petroleum: Pervasive Influence and Projections 35

IV. Potential New Uses 48

V. Analysis of the Most Promising New Uses 79

I. INTRODUCTION

> Nothing is permanent but change.
>
> Heraclitus,
> 500 B.C.

> "Change is the law of life. And those who look only to the past or the present are sure to miss the future.
>
> John F. Kennedy
> June 25, 1963

During the past 20 years corn growers have been buffeted by dramatic changes. In 1964, 46 percent of corn never left the farm where it was produced (Fig. I.1). Corn farmers fed it to livestock on their own farm. By 1979 when the estimates were discontinued that percentage had declined to 39 percent. Another 30 percent of total corn usage in 1964 was consumed by livestock off the farm where it was produced, resulting in livestock consumption of over 76 percent of the total corn used in 1964. By 1984 total feed usage had declined to 59 percent of total utilization (Fig. I.2).

Fig. I.1 Corn Usage in 1964

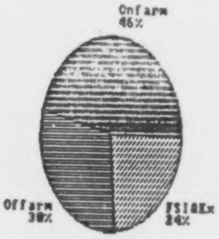
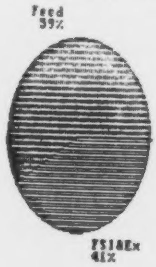


Fig. I.2 Corn Usage in 1984



Corn farmers have responded quickly to the availability of improved production technologies. Consequently, average yields have almost doubled in 20 years (Fig. I.3).

Fig. I.3 Corn Yields

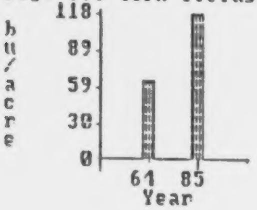
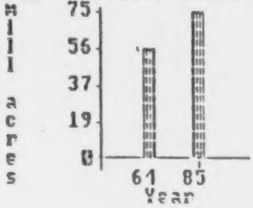


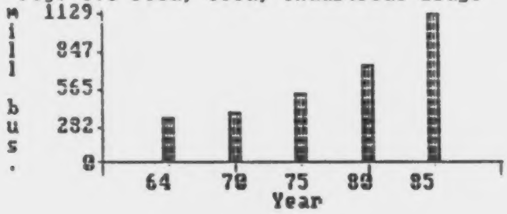
Fig. I.4 Corn Acres



Corn farmers responded to the highest real prices since the early part of this century and to the public concern for possible worldwide food shortages by increasing acreage harvested from 63 million in 1964 to an all time high of 74.8 million in 1985.

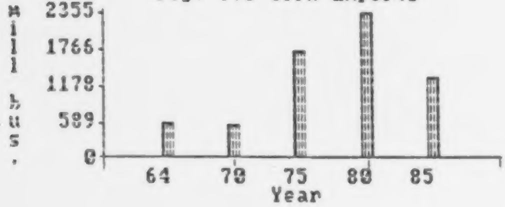
Throughout the decade of the sixties food, seed and industrial (FSI) usage was stagnant at less than 365 million bushels. But in the past decade FSI usage has more than doubled.

Fig. I.5 Food, Seed, Industrial Usage



Exports were also relatively stagnant until they doubled in the growth decade of the seventies. But the confluence of the following factors have produced a dramatic decline in corn exports since 1981.

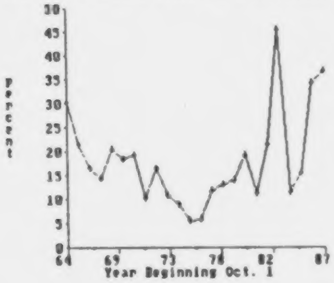
Fig. I.6 Corn Exports



- Several years of strong demand relative to supply produced good market prices and high support price levels in the early eighties.
- After several years of weakness against other currencies, a change in U.S. monetary policy in 1981 produced a strong dollar and dramatically increased U.S. corn prices as stated in foreign currencies (even though corn prices inside the U.S. were declining).
- Some of the strong demand in developing countries was generated by cheap food policies, expansive monetary and fiscal policies and excessive debt accumulation, all of which changed suddenly when their foreign debts reached unmanageable levels in the early eighties.
- After steadily losing market share to the U.S., several feed grain exporting countries effected policy changes in the early eighties, thereby making their feedgrains more competitive against U.S. corn.
- Worldwide economic recession exacerbated the above factors and dampened feedgrain demand in all countries, including the U.S. livestock industry.

As a result of such dramatic changes carryover stocks have ranged from 30 percent of supply in 1964 to a low of 6 percent in 1975 and up to a record of 45 percent in 1982. And after being drawn down dramatically by the PIK program in 1983 they are back up to over 35 percent.

Fig. 1.7 Beginning Stocks as % of Supply



Corn growers don't have to be reminded of the effects of these changes and the disastrously low prices on farm incomes. In the last three years the number of corn producers has declined dramatically and it appears nothing will stop further decline. Remaining corn producers have been forced to become more sophisticated in all aspects of production, marketing and group action. Evidence of the latter is the rapid increase in the number of state corn promotion checkoffs and the decision by state associations to breathe new life into the National Corn Growers Association.

Market Planning in a Changing World

The often quoted statement that "those who fail to understand history are doomed to repeat it" may be overused but it is nevertheless relevant in this case. Another often used statement is also relevant for corn growers in these difficult times; "change is inevitable in our society and only those who adapt to change can survive". The decision by corn growers to carry out the current alternative use survey is a reflection of a basic understanding of those principles.

But the evidence suggests that corn farmers are faced with a need to go beyond simply avoiding the mistakes of the past or even creatively adapting to change. We believe that corn farmers can, for the first time, realistically expect to manage several of the variables which produce change and thereby gain some control over the changes which will inevitably come.

Large scale non agricultural industries in the United States long ago recognized three business principles which now fundamentally guide their management decisions.

1. To avoid devastating costly over or under supply conditions, supply control disciplines must be pursued collectively. In most basic industries that collective supply control is facilitated by the reduction of competitors to a small number (5 to 100) with clearly dominant firms leading the way in terms of production control. GM and IBM are examples of leadership in two basic U.S. industries.

2. New markets for old products or new products for old markets must be constantly and aggressively pursued if the firm is to survive in a constantly changing economic and social environment. GM and IBM have both been forced to develop significant new products and marketing strategies as a result of changes which have led to smaller cars and smaller more powerful computers.
3. Marketing strategies must be pursued which provide the broadest possible range of product uses and customers as a hedge against the risks of loss of sales to any one market segment or customer. The range of products and market segments served by IBM and GM is baffling.

While these three fundamental business principles are inextricably intertwined, this report is concerned primarily with the latter two. We believe that corn growers can realistically expect to use the mechanisms already in place to collectively identify and develop some exciting new markets. The impressive recent success of two new uses for corn (sweeteners and ethanol) establishes the precedent. But it won't be easy and it can't be done on a shoestring. New product development and market introduction is a long, arduous and expensive process. It will require commitment, discipline, sophisticated skills and persistence.

This report identifies only a few of the thousands of potential new uses for corn and its derivatives. A few appear sufficiently attractive and well enough advanced to warrant immediate expenditure of corn grower resources in bringing them into reality in the relatively near future. But this research only scratches the surface. We have therefore recommended a strategy for corn grower intervention in the promotion of basic research which can produce fundamental breakthroughs as well as applied research in the identification of new market opportunities and the design and promotion of the specific products which can economically compete in those markets.

Plan of This Report

The following chapter further reviews the essence of change in corn markets in the past twenty years and demonstrates the limitations of dependence on traditional markets, e.g. livestock feeds or traditional food products. It also documents the range of products which are already being derived from the corn plant and provides a glimpse of the potential for future product development.

Corn can theoretically be used as a feedstock to produce most of the products currently derived from petroleum and other fossil fuels. But corn has the long term advantage of being a renewable resource. It is also more American than apple pie and certainly more American than OPEC oil. Nevertheless, its not enough to say corn can theoretically replace other raw materials; it must be economically competitive. Chapter III, therefore, reviews the current and projected supply, demand and price situation for petroleum, the raw material whose abundance and versatility has, in the opinion of many, been fundamental in the economic success of the United States and indeed all advanced economies.[1/]

Chapter IV provides a brief description of several potential new uses for corn which were uncovered in this research. The chapter serves to illustrate the amazing variety of potential uses for the derivatives of the corn plant. Several of the products are the result of developments which have been patented for years and have never been taken further, either because the process has not been perfected by further development and/or the economics have not been right. Others are still in some phase of basic or applied research. It is important to recognize that the process of identifying, developing and marketing a new product is long and demanding. While there are always exceptions, the normal steps are:

1. Basic research to identify the theoretical idea or further some of the technical processes necessary for eventual commercial exploitation;
2. Applied research at "bench or laboratory" scale to develop the specific process required to produce a particular product in small quantities without regard to unit cost;
3. Applied economic and market research to determine the likely cost of production, price and market constraints and to evaluate the potential profitability of the product;

[1/] John Gever, et. al., Beyond Oil: The Threat to Food and Fuel in the Coming Decades, Ballinger Publishing Company, Cambridge, Massachusetts, 1986, pp. 75-84.

4. Pilot scale production to develop the commercial production process and provide a limited amount of the product which can be market tested;
5. Market testing to determine product acceptability and/or to identify problems which must be ironed out before going to full production and to serve as a basis for a final decision on the advisability of proceeding with the required investment.

Seldom can a new product be taken through those five necessary development stages in less than five years and most require 10 to 20 years and millions of dollars. For example, the research budget of DuPont Company is reported to be $1.5 billion per year. And Monsanto spends over $500 million per year with $40 million farmed out to a single university for basic research.

While corn growers need to understand the above, they should not be intimidated by the complexity and costliness of the product development task. Chapter V offers specific strategies for corn growers to get maximum benefit from their relatively limited economic resources, through judicious use of the significant purchasing power with input suppliers and processors and their considerable political power.

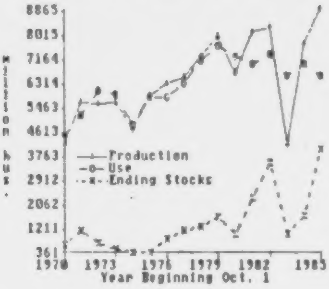
In Chapter VI specific suggestions are made for applying the suggested strategy to hasten the commercialization of the more promising new products described in Chapter IV.

II. CORN MARKETS: PAST AND FUTURE

As a basis for formulating realistic plans for the future it is important to fully understand the past and the forces that have shaped the present. In this chapter we will more completely explore developments in the production and utilization of corn. We will demonstrate that U.S. corn farmers can efficiently produce almost any reasonable quantity of corn that may be required by growing markets. We will explore the current corn processing industries and examine some of the multiple products which are already being produced and marketed from the corn plant and it's derivatives. We will examine one set of corn supply and demand projections based on the assumption that no new market uses are developed and understand why it is urgent that corn farmers pull out all stops to develop and diversify their markets. Finally, we will derive certain conclusions from the analysis with regard to the indicated market development strategies for corn growers.

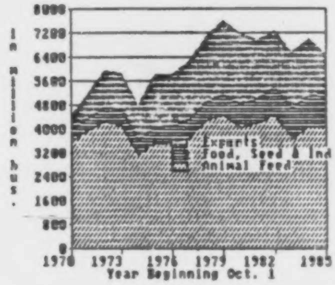
It is increasingly clear that the decade of the seventies was an unusual period with respect to development of corn markets. After suffering through the surpluses of the fifties and sixties, corn farmers were introduced to a new era of rapidly growing export demand for their product. Livestock producers in Japan, Western Europe and numerous other countries were responding to strong demand for livestock products brought on by sustained personal income growth and consumer desire to improve their diets. Later in the seventies corn sweeteners and ethanol product demand provided additional strength to corn markets. Corn producers and their technology suppliers responded with dramatic improvements in productivity and acreage. Figure II.1 shows the strong upward trend in corn production throughout the seventies. Note that total corn utilization moved up in tandem with production, without excessive carryover stocks. But the change in U.S. monetary policies along with the other factors mentioned in the last chapter had a double effect on corn farmers; it dampened export and domestic demand for their product and it increased interest costs on debt accumulated in the seventies when they were scrambling to keep up with product demand. The result has been the most rapid and massive build up in surplus corn stocks ever.

Fig. II.1 Production, Use and Stocks



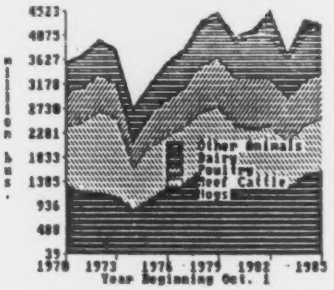
For decades prior to 1970 corn was used primarily as an animal feed on or near the farm where it was produced; and prior to that it was used primarily for direct human consumption (Fig. II.2).

Fig. II.2 Major Corn Uses



Abundant and inexpensive corn in the fifties and sixties, coupled with rapidly rising discretionary incomes resulted in a dramatic expansion in livestock production and consumption. But by 1970 the growth in feed consumption of corn had slowed somewhat, though economic prosperity continued to fuel substantial growth in animal product consumption and in corn demand. It appears that by about 1980 U.S. consumers had begun to approach a level of animal product saturation.

Fig. II.3 Feed Use By Livestock



In the meantime, the dietary revolution which had swept the U.S. in the fifties and sixties was catching on in many foreign countries where incomes were increasing rapidly. As a consequence corn exports became the most dynamic component of corn usage throughout the seventies. But, as noted earlier, that bubble was rudely burst in 1980.

Direct human corn consumption reached a peak in the U.S. many years ago, but was given a dramatic boost in the late seventies with the introduction of high fructose corn sweeteners. Another major breakthrough came in the late seventies when corn growers used their influence to establish the first significant non food market for corn with the development of ethanol fuel production. These two developments have set the stage for what is likely to be the next engine of growth in corn demand.

Corn growers have demonstrated that productivity can be increased in response to effective demand (See Figure II.4).

Fig. II.4 U.S. Corn Yields Per Acre

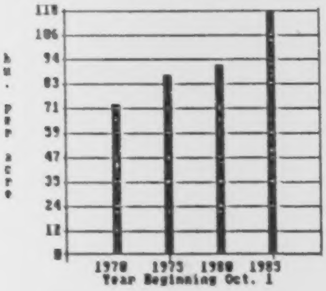
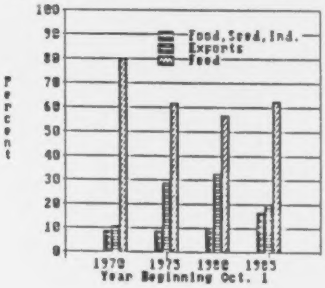


Figure II.5 provides a useful summary of the changes in corn utilization over the past fifteen years. In 1970 domestic feed usage represented about 80 percent of total corn utilization, but by 1975 it had dropped to about 60 percent and has remained there. In the meantime exports expanded their market share rapidly in the early seventies but declined in the last few years. Food, seed and industrial uses have nearly doubled their market share in this decade.

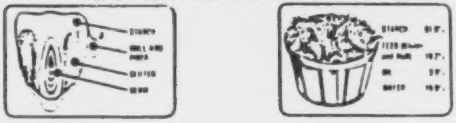
Fig. II.5 Percent Disappearance By Use



Corn Processing Technology and Products

The kernel of corn is a potent combination of starch, protein, polyunsaturated oil and hull (primarily cellulose). The following figure shows the relative location of each component in the kernel and the relative quantities of each.

Figure II.6 Corn Kernel Contents



To release the potential of the corn kernel, there are three major types of corn grain processing technologies at this time. A quick review of each will provide useful background information on this, the most dynamic component of corn grain utilization and give some indication of the range of corn product derivatives being marketed.

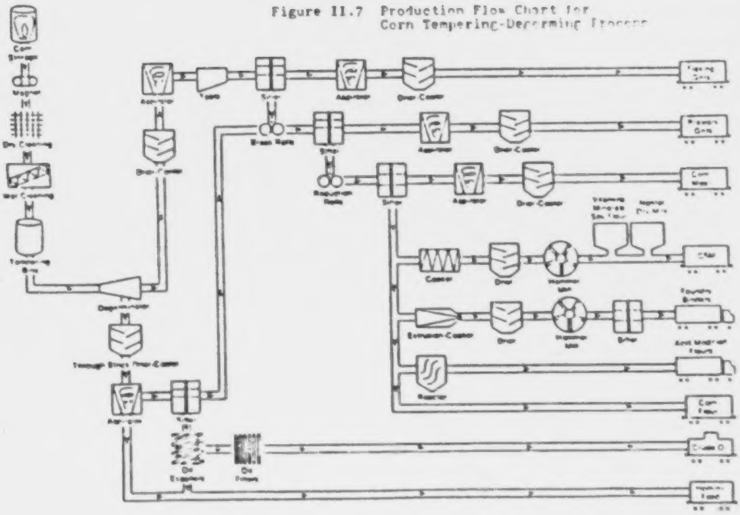
Dry Milling

The major products of the corn dry milling process are flaking grits, used primarily in breakfast cereals, brewers grits, corn meal, corn flour, hominy feed and in some cases corn oil. All but hominy feed are used for direct human consumption.

The following is a concise description of the process.

> A typical production flow chart for the tempering-degerming process used by the large dry corn millers is shown in Fig. II.7. The cleaned corn is tempered to 20% moisture, It is then dehulled and degermed. The tail hominy fraction, which contains the bulk of the corn endosperm, is screened to yield the large flaking grits (used to produce corn flakes) and reduced in size on corrugated rolls to produce smaller grits (brewers grits, etc.), meals, and flours.
>
> The through stock fraction contains bran, germ, and the high fat-containing endosperm streams. This fraction is dried and the germ portion is expelled or solvent extracted to produce crude corn oil. The oil-extracted germ cake, bran, and high fat endosperm streams are combined and sold as hominy feed. 2/

Figure II.7 Production Flow Chart for Corn Tempering-Degerming Process


Corn Storage
Dry Cleaning
Wet Cleaning
Tempering Bin
Aspirator
Sifter
Aspirator
Drier-Cooler
Flaking Grits
Drier-Cooler
Break Rolls
Sifter
Aspirator
Drier-Cooler
Reduction Rolls
Sifter
Aspirator
Drier-Cooler
Corn Meal
Cooker
Drier
Hammer Mill
Extrusion-Cooker
Drier
Hammer Mill
Sifter
Corn Flour
Degerminator
Through Stock Drier-Cooler
Aspirator
Sifter
Oil Expellers
Oil Filters
Crude Oil
Hominy Feed

2/ Gordon H. Wells, "The Dry Side of Corn Milling", Cereal Foods World, The American Association of Cereal Chemists, 1979, p. 333.

Dry milling product demand has been relatively stable for several years, with small increases due to population growth.

Wet Milling

Wet milling or refining plants separate corn grain into four major components from which numerous products can be derived:

(1) germ, from which edible oil is expelled using solvent extraction technology;

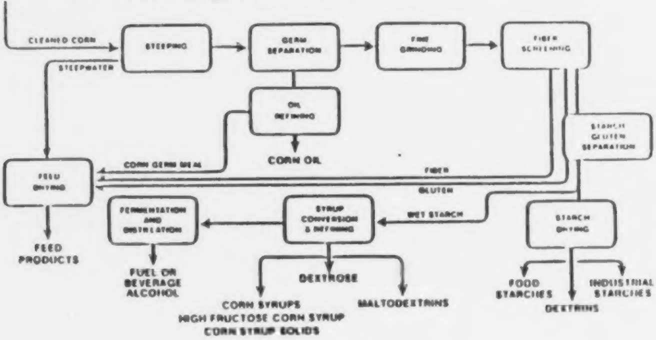
(2) starch, which can be modified in various ways to fit industrial, food, drug and cosmetic applications, or it can be fermented to produce ethanol, or it can be converted to glucose, dextrose, maltodextrins and high fructose corn sweeteners;

(3) gluten and hulls, which goes primarily into animal feeds with gluten meal having a high protein content of about 60 percent and being used mostly in poultry feed and gluten feed having a lower protein content of 22 percent and higher cellulose content going primarily into ruminant feeds;

(4) steepwater, the water used to soak the grain at the beginning of the process and ending up with soluble nutrients which are used in antibiotics, chemicals, yeasts and also for animal feed.

Figure II.8 depicts the process. The corn is cleaned before going into steep tanks for soaking in warm water for 30 to 40 hours. The

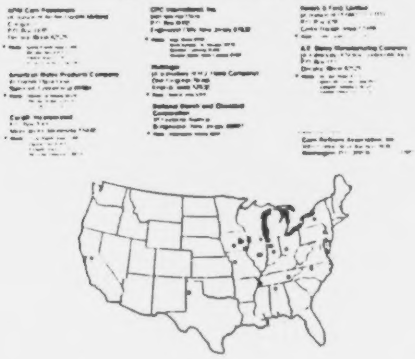
The corn refining process... Figure II.8


CLEANED CORN
STEEPING
GERM SEPARATION
FINE GRINDING
FIBER SCREENING
STEEPWATER
OIL REFINING
STARCH GLUTEN SEPARATION
CORN GERM MEAL
CORN OIL
FIBER
FEED DRYING
GLUTEN
WET STARCH
FERMENTATION AND DISTILLATION
SYRUP CONVERSION & REFINING
STARCH DRYING
FEED PRODUCTS
FUEL OR BEVERAGE ALCOHOL
DEXTROSE
CORN SYRUPS
HIGH FRUCTOSE CORN SYRUP
CORN SYRUP SOLIDS
MALTODEXTRINS
FOOD STARCHES
DEXTRINS
INDUSTRIAL STARCHES

steepwater is drawn off, and the softened kernels go to degerminating mills and separators where the oil-laden germs are removed and the oil extracted. The remaining slurry of starch, gluten and hulls is ground finely and passed through screens for removal of hulls. Starch and gluten are then prepared for shipment as starch, or converted to sweeteners or alcohol.[3/]

Corn refining plants are typically very large scale, computer controlled and highly capital intensive. Most have been built or significantly remodeled in the last 15 years. Ten large companies operate 25 plants concentrated primarily in the midwest. Members of the corn refiners trade association and their plant locations are shown in Figure II.9.

Figure II.9 Corn Wet Millers



[3/] "Tapping the Treasure of Corn", Corn Refiners Association, Washington, D.C.

Fermentation of Whole Corn for Ethanol

The conversion of whole grain to alcohol is a straight forward process. It has been used for years in the production of beverage alcohol. The grain is first cleaned and ground into meal and then cooked in water to gelatinize the starch. The liquid substance, known as the mash, is cooled to around 50 to 60 degrees and mixed with about 10 percent malt slurry to convert the starch to sugar. The mash is cooled and pumped into fermentation vats where yeast is added. The solution is allowed to ferment for a period of between 72 and 96 hours yielding "beer" with an alcohol content of around 10 percent. The alcohol is then removed from the beer by distillation which produces a solution with a maximum ethanol content of 95.6 percent. Further distillation with the addition of benzene or a similar chemical removes the remainder of the water and yields the product, "dry ethanol".

The spent mash is filtered and dried to produce a valuable feed component known as "distillers' dried grains with solubles". Some manufacturers dry and sell the distillers' dried grains and the solubles separately but the bulk is sold in combined form as a livestock feed.[4/]

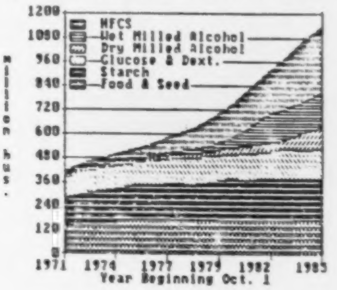
With existing technology, a bushel of corn processed in dry mills yields about 2.57 gallons of 190 proof ethanol and 17.85 pounds of distillers dried grains with solubles.

[4/] Stanley A. Watson, "Industrial Utilization of Corn", Corn and Corn Improvement. G.F. Sprague, (Ed.) Agronomy 18, American Society of Agronomy, Madison Wisconsin, 1977, pp. 721-763.

Recent Industrial Growth Markets

Practically every corn grower is aware that the only expanding component in the corn market picture in the last few years has been the usage of corn to produce high fructose corn sweeteners and fuel alcohol.

Fig.II.10 Food, Seed, Industrial Uses



Corn Sweeteners

Corn syrup (glucose and dextrose) has been available and used in numerous food applications for many years. But the very characteristics that make those corn syrups desirable for certain uses served as a limitation for broader sweetener applications. The corn wet miller grind had, therefore, reached what seemed to be a plateau in 1968 at about 200 million bushels. But the introduction of a new process to produce high fructose corn syrup in that year introduced a new dynamic in the market.

The scientific breakthrough, discovery of an isomerase enzyme, which made HFCS possible was achieved in a medical laboratory not by corn product researchers. It was applied to corn by a wet miller in 1957 but abandoned as not commercially viable. In the early sixties Japanese researchers found a new way to produce the enzyme and licensed the enzyme to a second U.S. wet miller. That company first commercialized the product in 1968, but there were plenty of quality problems and the economics were far from ideal. Nevertheless, other wet millers obtained licenses and began to make their own proprietary improvements. According to Richard Hahn, Director of Research for A. E. Staley, growth was slow in the early years, but in the mid seventies three factors came together to produce explosive growth in the industry:

(1) rapid escalation of sugar prices;

(2) new and more economic processes were available;

(3) quality improvements were made.[5/]

The soft drink sweetener market was difficult to break into but now represents the largest single market for HFCS. In 1985 per

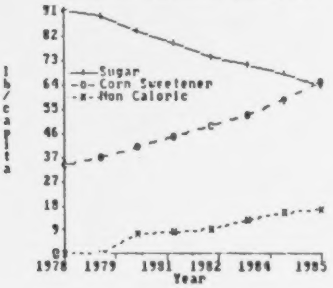


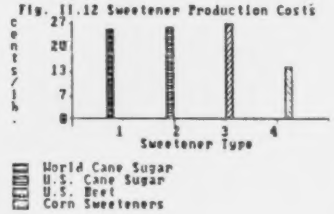
Fig. II.11 Sweetener Consumption

[5/] Richard Hahn, Vice President, Research & Development and Quality Assurance, A.E. Staley Manufacturing Company, Decatur, Illinois. "Corn Wet Milling Opportunity", a speech delivered at an Indiana state conference entitled "Value Added for Agribusiness" on February 13, 1986.

capita consumption of corn sweeteners surpassed sugar for the first time.

It is estimated that corn sweeteners accounted for about 500 million bushels of corn in 1985 and added about 25 cents per bushel to the price of corn. In the final analysis corn sweeteners have been successful because they are a lower cost high quality alternative to other sweeteners.

Fig. II.12 Sweetener Production Costs



On June 26, 1986 Staley Continental, Inc. announced a major breakthrough in corn sweetener production. In 1987 the company will begin producing and marketing the first chrystalline fructose products. "Chrystar", the trade name for the new product, will initially be positioned for use in processed food applications. This development is expected to give additional impetus to the corn sweetener market which had showed signs of peaking after all major soft drink companies had recently completed the switch to HFCS.

In his speech on February 13, 1986 Dr. Richard Hahn suggested that the following lessons could be learned from the corn sweetener experience.

(1) Basic non mission oriented research on issues related to product utilization is important. In the case of HFCS it came from medically oriented research.

(2) Sources of technology may be outside an industry and outside the U.S..

(3) New products should be developed even if the current economics is not attractive enough to warrant introduction - the situation may change as it did for corn sweeteners.

(4) The new product must economically fill a need with acceptable quality and functionality .

(5) Risk takers are required who will provide the capital and creative human resources to successfully introduce the product.

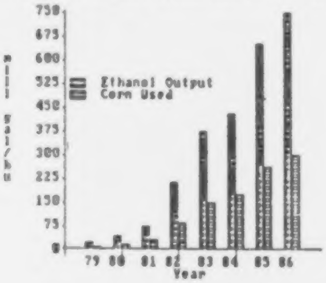
(6) Patience is essential. A major innovation requires a long time - ten years or longer is not unusual before a product is successfully launched.

(7) Certain critical technical and financial inputs are essential, e.g. scientific capabilities in the relevant disciplines, unique research and development facilities, process engineering capabilities, and adequate financing capabilities.

Ethanol

The second major growth market for corn has been for the production of fuel ethanol. The technology for producing ethanol from corn has been around for centuries. But until the Arab oil embargo in 1974 and the ensuing oil price increases little consideration was given to ethanol as a fuel because of it's high cost compared to petroleum fuels. Federal and state excise tax exemptions supported by corn growers provided the economic stimulus needed to get ethanol introduced as a fuel additive in gasoline. And environmental concerns about the detrimental effect of lead additives in gasoline has provided additional growth opportunities for ethanol since it improves the octane rating of gasoline without harmful emissions. Ethanol production and corn usage for that purpose have skyrocketed.

Fig. II.13 Ethanol Production & Corn Use



On January 1, 1986 new EPA regulations went into effect, reducing significantly the amount of lead which can be used in regular gasolines. The result is expected to increase ethanol usage in the near term. Corn growers and the ethanol industry have set a goal for producing 2.5 billion gallons of ethanol using 1 billion bushels of corn by 1990.

Achieving that goal will depend on the industry's ability to meet stiff competition from other octane enhancers by reducing production costs and to counter a growing misconception in some circles that ethanol is harmful to engines, especially fuel injectors. While many companies in the ethanol industry have made marginal plant design improvements and achieved significant economies of scale in production, there has been no breakthrough in the basic conversion rate of corn to ethanol. It still takes about

2.5 bushels of corn to produce a gallon of ethanol. Furthermore, it is quite possible that within the next few years, processes will be developed to commercially convert cellulose to ethanol, making waste biomass viable as a feedstock for the first time and reducing the cost of production significantly. Work has been underway on that subject for several years in various places. Corn growers must stay abreast of those developments and be prepared to adapt, for example with the changes necessary to make corn stover a viable feedstock using the new processes.

The precipitous drop in the price of gasoline in early 1986 is now having a serious effect on the ethanol market. Information Resources, Inc. (a company which monitors ethanol industry developments) believes that monthly ethanol production figures, which were fairly high in the first half of this year are beginning to decline. Consequently their projection of total output for 1986 is lower than had been expected given ethanol production capacity and production levels in the last few years.

Finally, the six cent federal alcohol fuel tax exemption and many state exemptions are scheduled to expire on December 31, 1992.[6/]

All of these developments suggest that, while corn growers must aggressively work with ethanol producers to protect and expand this significant new market for corn, adjustments must also be contemplated to offset the risk of loss of part or all of that

---

[6/] Mohinder Gill, "Alcohol Fuels in the U.S.: Status and Prospects," Outlook and Situation Report, U.S. Department of Agriculture, Economic Research Service, August 1984, pp. 10-15.

market. Businessmen in our dynamic market economy are constantly faced with difficult decisions to close out unprofitable product lines or production facilities when they are no longer competitive in the market place. But the companies which thrive over the long run are those which have had the foresight to do the research and testing of new products and processes which can be brought onstream to replace the revenue lost by that painful pruning of old products and facilities. If the 1985 farm bill, as claimed by many, is a step toward returning farm products to a free market then it becomes even more urgent for corn farmers to learn how to function according to the marketing principles needed to survive in a dynamic market economy.

Milling Feed By-products

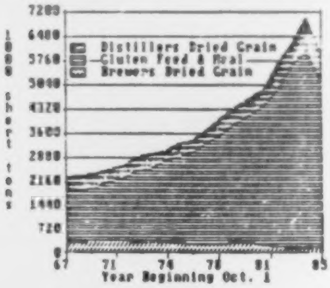
All three of the milling technologies described above produce significant quantities of by-products. The following quantities of feed by-products are derived from each bushel of grain processed.

(1) Dry milling by-products:
20 pounds of hominy feed (a mixture of corn bran, whole or de-oiled germ and gluten meal and part of the starchy portion of the kernel

(2) Wet milling by-products:
2.6 pounds of gluten meal (a 60 percent protein feed produced by separating the gluten from the starch in the corn germ) 12.8 pounds of gluten feed (a 22 percent protein feed combining gluten, hulls, gluten meal, concentrated steep water and corn oil meal)

(3) Whole grain fermentation:
17.8 pounds of distillers dried grains with solubles (a 27 percent protein feed composed of left over gluten, germ and hulls.

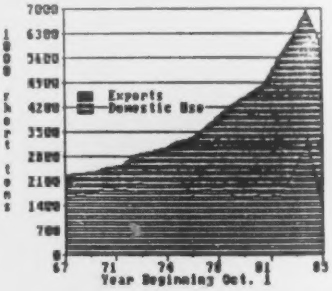
Fig. II.14 Milling By-Product Production



The major if not sole market for those by-products has been the livestock feeding industry either in the U.S. or abroad. The increase in the volume of corn milled for sweeteners and alcohol has therefore produced a concomitant increase in the volume of feed by-products on the market. In 1984 total production reached a record of nearly 7 million short tons.

As Figure II.15 illustrates export markets have absorbed most of that increased production. Actually the European Economic Community has been the recipient of practically all of

Fig. II.15 By-Product Utilization



that increase. The vast majority of that quantity is corn gluten feed and most of it goes into West Germany, the Netherlands and Belgium. The explanation for the EC absorption of such large quantities is the fact that the Common Agricultural Policy has provided high feed grain support prices protected by variable import levies on imported grain. But corn gluten feed, soybean meal and many other non-grain feeds enter the EC duty free as a result of a zero tariff binding agreement under the GATT. Corn gluten feed is therefore relatively cheap as compared to other feeds in the EC.

However, the EC Council of Ministers has recommended a duty free import limit of 3 million tons on corn gluten feed. The United States has vigorously opposed that proposal and threatened to impose import quotas on wine and other large EC imports if the EC proceeds. In the last three years gluten feed exports to the EC have hovered just below 4 million tons. A three million ton duty free quota would, therefore, expose about 1 million tons to a variable duty and further erode the principle of free trade.

In any case, there is reasonable doubt that the EC will continue to absorb unlimited quantities of corn gluten feed. If ethanol and sweetener production should continue to rise there could be serious downward pressure on by-product prices and on corn prices due to excess by-product supplies. This implies the need to identify new uses for the non-starch portion of the corn kernel.

Projections for the Future

Predicting the future is never easy and usually brings with it the seeds of it's own failure. It is difficult because no one can anticipate all the millions of important and seemingly unimportant events which will interact to drive the variables which one wishes to predict. And while the past is the only basis we have as a reference, there is certainly no particular reason to expect that all the factors which influenced the past will continue unchanged. In fact, we can probably be certain that some things will change and maybe dramatically. Predictions often bring with them the seeds of their own failure because the very act of predicting is usually done with the purpose of anticipating what may come and attempting to alter behavior to mitigate the undesirable aspects of the predictions. With those caveats, the following is an imperfect but important look at the ten year outlook for the corn industry under currently reasonable assumptions. The numbers were derived from a large and completely interactive econometric model of the entire U.S. agricultural sector including both domestic and international economic linkages by highly qualified economists.

It seems clear that the current burdensome stocks of corn will dramatically influence the supply and demand situation for some period of time. Of course, that length of time will also be affected by the volume of corn produced in the world and especially in the U.S. and the amount of corn used up. Figure II.16 shows supply, demand and beginning stock projections based on support price, target price and set aside provisions of the 1985 farm bill and current best estimates of usage rates.

Fig. II.16 Supply and Demand Projections

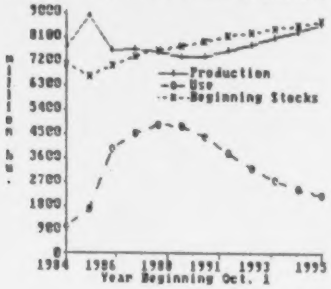
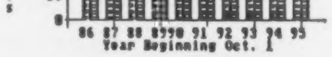


Figure II.17 shows that yields are expected to continue to increase up to 125 bushels per acre in 1995. Acreage is expected to decline slightly through 1990 and then increase slowly as demand and supply are brought into somewhat better balance.

Fig. II.17 Projected Acreage & Yields



In order to help put these numbers into some practical perspective consider the following. It looks like that for the next decade annual corn production could easily average 8.6 billion bushels. The utilization rate in 1986-87 is expected to be about 7 billion bushels. That leaves 1.6 billion bushels without a home. If all that corn were loaded on tractor trailers it would require over 2 million of them. You could have a truck convoy that would shock even Smokey and the Bandit. It would stretch out over 25,000 miles. The convoy could start at one side of Dain Friend's farm in Illinois, go all around the world and the last truck would end somewhere near the other side of Dain's farm. Thats-a-lotta-corn!

Hopefully utilization rates are underestimated. However, livestock usage is not likely to increase more rapidly than the projection, given current consumer attitudes and relatively stagnant consumption levels. While exports are not predicted to expand at the rapid rates experienced in the seventies or even the less optimistic rates expected by most export enthusiasts, current world conditions do not indicate that the lower support prices will affect consumption rates as much as might be expected because:

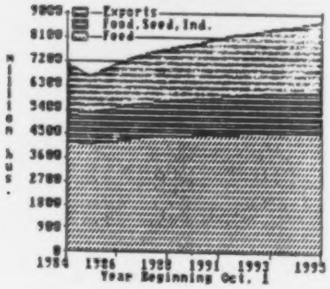
(1) the dollar is still quite strong against most developing countries and other exporting countries;

(2) purchasing power in many countries is still not increasing nor is the foreign exchange situation for many countries significantly improved;

(3) lower world and U.S. prices are not likely to be fully reflected in many countries;

(4) many countries are instituting domestic production initiatives to promote internal development and save scarce foreign exchange.

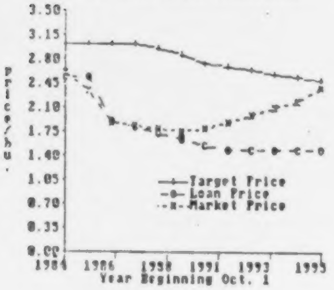
Fig. 17.18 Projected Utilization



Industrial usage may well be underestimated especially given the announcement that a chrystalline sweetener will be introduced next year. But other than that sweetener sales seem to be leveling off. And the current low price of petroleum will keep ethanol sales from growing as rapidly as they otherwise might. Of course, if and when oil prices move back closer to the levels of the past few years ethanol sales may increase more rapidly. But even if FSI usage turns out to be 50 percent higher than these projected levels the basic supply and demand relationships would not improve significantly. What is needed is a simultaneous increase in domestic feed consumption, exports and FSI usage coupled with a significant drop in production for a year or two.

Expected support and target price assumptions as outlined in the 1985 farm bill as well as market price expectations are shown in the following figure.

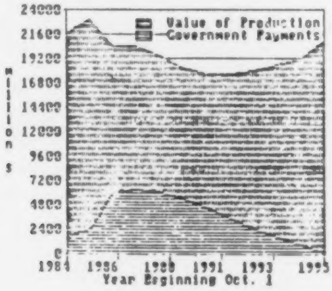
Fig. II.19 Price Projections



Support prices continue to decline through 1991 as do target prices while market prices begin to recover in that same year.

As one might expect the effect on gross income for corn producers is not very encouraging and much of it will come from government payments (Figure II.20).

Fig. II.20 Gross Income Projections



Obviously, those price and income projections would be improved if somehow supply and demand could be brought into better balance sooner.

Implications

Aside from documenting what many have anticipated, what are the implications of the foregoing analysis?

(1) Corn production capacity is significantly out of balance with utilization rates and looks like it will stay that way for the next decade. The annual excess capacity is about 1.6 billion bushels.

(2) Corn support and market prices are, therefore, likely to be extremely low for the next several years. If that is the case and is not changed significantly by political action, then at least the silver lining is that corn will be an attractively priced material for whatever new uses can be promoted.

(3) Even if existing market uses and exports are promoted aggressively there appears to be little likelihood of turning the situation around dramatically. And one might argue that economic forces are sufficiently strong as to render traditional promotional activities relatively ineffective in light of the magnitude of the supply.

(4) Sizable new uses like the ethanol or sweetener markets are urgently needed. And they must be markets capable of absorbing large quantities of corn and/or corn derivatives such as feed by-products.

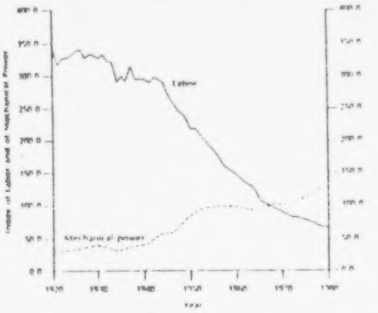
(5) Unfortunately, the development work for new market uses has not been done and there is no likelihood of stumbling onto technologies which can be easily brought on stream in less than 3 to 5 years.

(6) In light of the urgency for new market outlets as soon as possible, the alternative use promotion should focus heavily on those new uses with greatest short term high volume market potential.

III. PETROLEUM: PERVASIVE INFLUENCE AND PROJECTIONS

U.S. agriculture has become more heavily dependent on petroleum than any of us realizes. Without cheap and abundant petroleum resources it is highly unlikely that the oft heralded miracles of modern U.S. agriculture would be a reality. Petroleum based energy has replaced millions of farm workers with mechanical power in the past century (Figure III.1).[1/]

Figure III.1 Index of the Contribution of Human Labor and Mechanical Power to On Farm Agriculture, 1920 to 1980

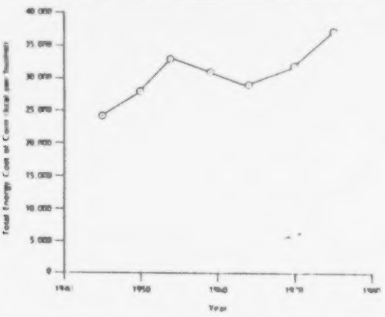


Source: Economic Research Service, USDA, Economic Indicators of the Farm Sector: Production and Efficiency Statistics, Statistical Bulletin 657 (Washington, D.C.: USDA, 1979).
Note: 1967 = 100

[1/] Much of the background information and ideas for this section were drawn from a fascinating and very useful study by researchers at the Complex Systems Research Center of the University of New Hampshire. John Gever, et.al., Beyond Oil: The Threat to Food and Fuel in the Coming Decades, Ballinger Publishing Company, Cambridge, Massachusetts, 1985.

Most of the yield increasing technologies such as the heavy fertilization so crucial to hybrid seed performance, the insecticides and herbicides, the irrigation water are all either derived directly from petroleum or require large amounts of petroleum based energy in their production. Figure III.2 shows the upward trend in the amount of energy required to produce a bushel of corn. It is an indisputable fact that U.S. agriculture has been increasingly petroleum dependent and has helped to reduce consumer living costs and improve our standard of living steadily.

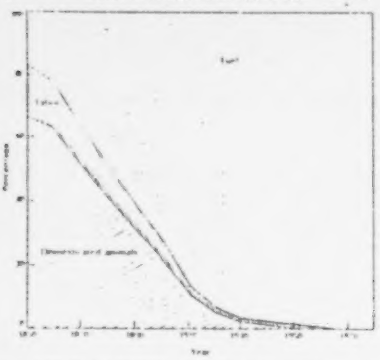
Figure III.2 Total Energy Cost of a Bushel of Corn, Including Energy Used to Make Chemicals and Machinery



Note: Circles represent data points

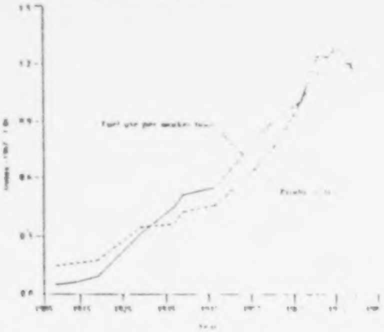
But agriculture is not the only sector of our economy dependent on petroleum, indeed our entire lifestyle has been built on cheap and abundant energy; and the continuation of that lifestyle is apparently dependent on continued availability of low cost energy (See Figures III.3 and III.4).

Figure III.3 Stacked Representation of Work Done over Time in the United States by Humans, Domesticated Animals, and Machines, as a Percentage of the Total Horsepower in the Economy



Source: C.A.S. Hall, C.J. Cleveland, and R. Kaufmann, Energy and Resource Quality: The Ecology of the Economic Process (New York: John Wiley & Sons, 1986).

Figure III.4 Historical Relations of Energy Use per Worker Hour and Labor Productivity in Output per Worker Hour

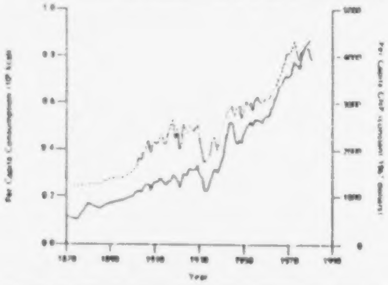


Source: C.J. Cleveland, R. Costanza, C.A.S. Hall, R. Kaufmann, "Energy and the U.S. Economy: A Biophysical Perspective," Science (1984) 225: 890-897.

Note: Solid line is energy use; dotted line is labor productivity. Both measures are indexes, 1967 = 1.0.

Our real gross national product growth over time has been closely correlated with per capita energy consumption levels (Figure III.5).

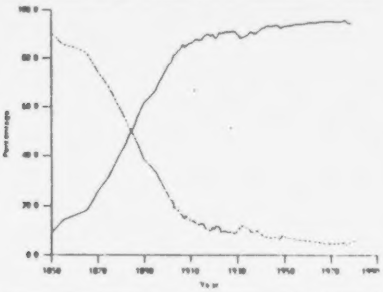
Figure III.5 Total Energy Use per Person in the United States and Real per Capita GNP, 1870 to 1980



Sources: U.S. Department of Commerce, Bureau of the Census, Historical Statistics of the United States, Colonial Times to 1970 (Washington, D.C.: USGPO, 1975); U.S. Department of Energy, Monthly Energy Review (Washington, D.C.: DOE, various years); U.S. Department of Energy, Energy Information Administration, Estimates of U.S. Wood Energy Consumption from 1949 to 1981 (Washington, D.C.: USGPO, 1982).
Note: Dotted line is per capita energy use; solid line is real per capita GNP.

Figure III.6 shows that the major source of energy to fuel economic growth has been nonrenewable fuels. In this century petroleum and natural gas have become the preferred fuel because of their low cost, versatility, transportability and economic efficiency. The investment in petroleum exploration, production, processing and distribution is enormous. Profits have also been enormous, generating huge amounts of revenue some of which could and has been plowed back into utilization research. It is, therefore, not surprising that millions of petroleum based products have been identified and commercialized in this century. Economic success breeds economic success. Multinational oil companies and government institutions spend many billions of dollars every year on research and development of petroleum derived products. In contrast, very limited research resources are dedicated to renewable energy research. The reasons are understandable since petroleum has been the most economical fuel. But evidence suggests that the situation may be different in the future.

Figure III.6 Percentage of U.S. Fuel Budget Supplied by Renewable Fuels and Nonrenewable Fuels



Note: Dotted line is renewable fuels; solid line is nonrenewable fuels.

Long Term Petroleum Projections

No one disputes the fact that the world has been rapidly depleting its known supplies of nonrenewable energy and that the depletion rate for oil has been particularly high. The world uses oil and gas at least 10,000 times faster than the earth's geological processes are replacing it. We are, of course, depleting the best and least expensive to extract supplies first, so our costs of production are going up.

The best projections of the energy costs and energy returns on oil and gas exploration show that *by 2005 it will be pointless to continue exploring for oil and gas as energy sources in the United States*. The energy cost for exploration will simply be too high in relation to the expected energy return.[8] The U.S. Department of Energy estimated proved U.S. oil reserves at 28.4 billion barrels in 1984, equivalent to less than 9 years supply at 1985 production rates. Although additional reserves will continue to be discovered, the outlook is for U.S. production to begin to decline soon. In contrast, proved crude oil reserves within OPEC were estimated at 477 billion barrels at the end of 1984, over 80 years supply at 1985 production rates.[9] A Harvard

---

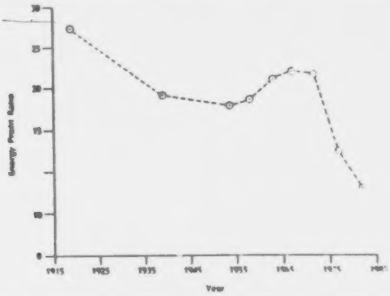
[8] Gever, et. al. op. cit., p.20.

[9] Energy Information Administration, *U.S. Crude oil, Natural Gas, and Natural Gas Liquids Reserves 1984 Annual Report* DOE/EIA-0216(84) and *Annual Energy Review 1984*, DOE/EIA-0384(84), Washington, D.C..

University study points out that energy consumption rates are likely to trend upward in response to the current lower oil price, especially if more moderate price levels are sustained for several consecutive months. The authors believe that consumption will increase and this growth will be driven by investment patterns which will materialize over time. 10/

The energy profit ratio is the energy in a particular fuel divided by the energy used to produce it. Figure III.7 shows that the energy profit ratio for domestic oil production has been declining sharply since 1974.

Figure III.7 Energy Profit Ratio for Domestic Petroleum



Sources: U.S. Department of Commerce, Bureau of the Census, *Historical Statistics of the United States: Colonial Times to 1970* (Washington, D.C.: USGPO, 1975); U.S. Department of Energy, *Monthly Energy Review* (Washington, D.C.: DOE, various years); U.S. Department of Commerce, Bureau of the Census, *Census of Mineral Industries* (Washington, D.C.: USGPO, various years).

Note: Includes only energy used to extract oil and gas, not energy used in transportation or refining.

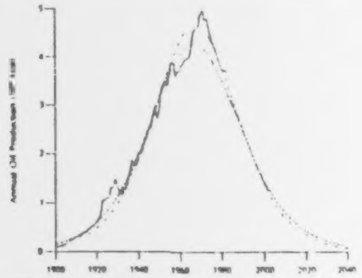
Another useful concept for evaluating oil and gas supplies is the so-called Hubbert analysis. In the 1950's a Shell Oil geologist named M.K. Hubbert derived a method to estimate U.S. oil

---

10/ William H. Hogan And Paul N. Leiby, Oil Market Risk Analysis H-85-03, Energy and Environmental Policy Center, Harvard Energy Security Program, Cambridge, Massachusetts, December 1985.

reserves and the rate at which they would be exploited in the future. The resulting Hubbert curve analysis has subsequently proven to be very accurate (Figure III.8). U.S. actual production levels have closely paralleled Hubbert's predictions. If his analysis continues to hold true domestic oil supplies will be effectively depleted and replaced by other energy sources by 2020. And even though we have much larger apparent reserves of natural gas, the Hubbert analysis indicates that gas reserves will also be effectively depleted by that same year (Figure III.9).

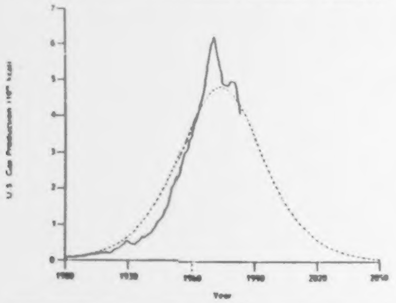
Figure III.8 Comparison of Hubbert Curve to Actual Production



Solid line is actual production; dotted line is Hubbert's 1956 curve; dashed dotted line is our updated curve based on 1981 data.

Sources: U.S. Department of Commerce, Bureau of the Census, *Historical Statistics of the United States, Colonial Times to 1970* (Washington, D.C.: USGPO, 1975); U.S. Department of Energy, *Monthly Energy Review* (Washington, D.C.: DOE, various years).

Figure III.9 Hubbert Curve for U.S. Gas Production and Actual Production



Sources: U.S. Department of Commerce, Bureau of the Census, *Historical Statistics of the United States, Colonial Times to 1970* (Washington D.C.: USGPO, 1975); U.S. Department of Energy, *Monthly Energy Review* (Washington D.C.: DOE, various years).

Many experts would disagree with the foregoing pessimistic gas and oil outlook because of their belief that unforeseen developments will bring about new technological improvements or alter demand patterns long before consumption rates permit depletion of our reserves. Our purpose here is not to argue the details, but simply to illustrate the possibility that in the longer run our reserves of nonrenewable energy are declining and their real cost is increasing. It is time to look more seriously at renewable resources as replacements for fossil energy and industrial feedstocks.

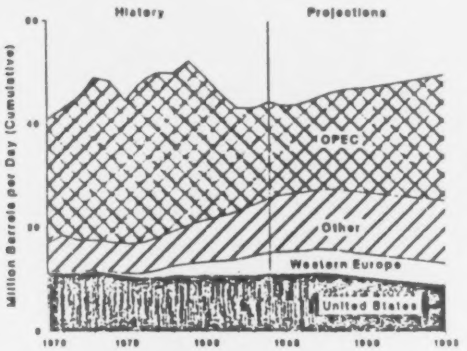
Short Term Oil and Gas Outlook

The preceding analysis indicated that the U.S. supply of oil and gas could be depleted within 30 years at current rates of production and consumption. It also indicated that the United States will face significant security risks due to dependence on imported supplies. This section focuses on projections for the next 10 years with special emphasis on petroleum price projections.[11/]

[11/] This discussion is based largely on a recent study by the Department of Energy using their econometric model to project U.S. and world production and consumption. International Energy Outlook 1985: With Projections to 1995, Energy Information Administration, DOE-IEA-0484(85) March 29, 1986.

The world energy situation has undergone significant changes in the past few years. The sharp increases in the price of oil in the seventies has resulted in improvements in energy conservation, energy efficiency and the use of alternative fuels throughout the world. Figure III.10 illustrates the high rates of oil production and consumption in the seventies and the sharp drop in production, mostly in OPEC, after 1978. Note that the International Energy Outlook by the Department of Energy shows U.S. production almost steady since 1970 and starting to decline in 1987. Meanwhile OPEC production is expected to increase throughout the decade.

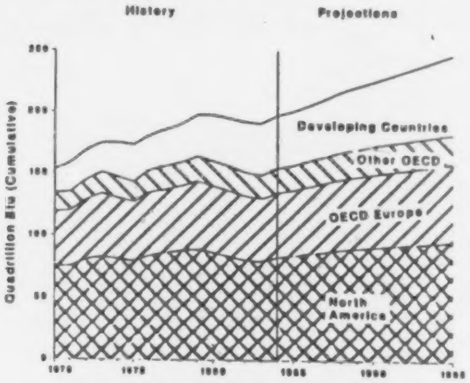
Figure III.10
**Market Economies Oil Production:
Base Case, 1970-95**



OPEC=Organization of Petroleum Exporting Countries.
Note: Production includes natural gas liquids, other liquids, and refinery gains.
Sources: o History: Energy Information Administration, International Energy Annual, DOE/EIA-0219, selected issues (Washington, DC).
o Projections: Table 9 of this report.

The DOE energy projection shows energy consumption increasing steadily in the industrialized market economies and quite rapidly in the developing countries (Figure III.11). It is interesting to note that energy consumption in the United States is significantly higher than all the developing countries combined, a reflection of the high energy consumption per capita in the United States and the low levels in the non-industrialized (maybe we should call them the non-energized) countries.

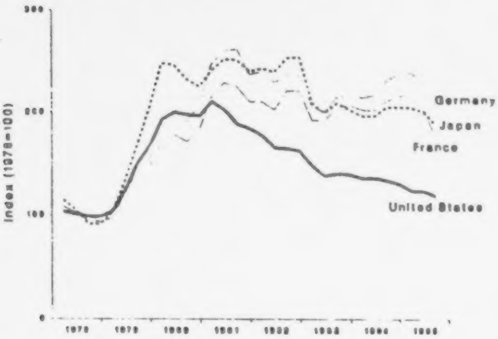
Figure III.11
Market Economies Consumption of Energy by Region: Base Case 1970-95



OECD=Organization for Economic Cooperation and Development.
Note: Other OECD includes Japan, Australia, New Zealand, and the United States territories.
Sources: o History: United Nations, 1979 Yearbook of World Energy Statistics (New York, NY, 1981); and Energy Information Administration, International Energy Annual, DOE/EIA-0219 and International Petroleum Annual, DOE/EIA-0042, selected issues (Washington, DC). o Projections: Table 11 of this report.

After the two oil price shocks of the seventies, U.S. oil prices peaked in 1980-81 at a level of $44 per barrel stated in 1985 dollars (Figure II.12). By November 1985 the price had dropped to $27 and in mid 1986 before the OPEC agreement to rollback production levels the international spot price fell as low as $8 per barrel. Real U.S. oil prices are well below European prices and are in fact lower than most countries.

Figure III.12
Real World Oil Prices in Major Industrial Countries
Based on National Currencies, 1978-85

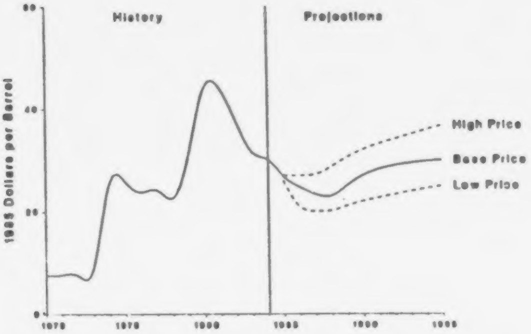


Note: The average refiner acquisition cost of imported crude oil in the United States is used as the world oil price for each country. The world oil price is converted to the national currency by using the appropriate exchange rate. This value is then converted to an index by dividing each quarterly value by the average value for 1978. Inflation rates for each country are used to determine real prices.

Sources: Energy Information Administration, Monthly Energy Review, DOE/EIA-0035(85/CR) (Washington, DC). Data Resources, Inc., U.S. Central, Europe, and Japan data bases.

World prices are extremely difficult to predict for reasons that have become painfully obvious to most of us in the last decade. The DOE projections handle that uncertainty by offering three different scenarios (Figure III.13). The base case is viewed as the most likely projection with a high and low case. Their prediction of a dip in prices has already been confirmed, but prices declined much faster and further than even the DOE low case anticipated. Many oil experts believe that cheap energy prices in the near term will increase U.S. dependence on imported oil. OPEC seems to be moving to keep prices at moderate levels for a period of time to push consumption back up and to drive out marginal production which is only profitable at relatively high prices. One expert observes that at $10 per barrel there would be no meaningful oil industry in the United States. He observes that at $10 per barrel nearly 41 percent of the stripper wells in the United States would be abandoned probably never to be reopened.

Figure III.13
World Oil Prices, 1970-95



Note: All prices are the cost of imported crude oil to U.S. refiners.
Sources: • History: Energy Information Administration, Annual Energy Review, 1984, DOE/EIA-0384(84) (Washington, DC, 1985). • Projections: Table 2 of this report.

The loss in domestic oil production would be 2.6 billion barrels. At $15 the industry is forced to enter into liquidation, and as a result there would be little or no exploration. With prices at $25 per barrel the industry would be fairly healthy with enough exploration and development to replace about 65 to 75 percent of our consumption.[12]

A group of researchers at Harvard University argue that OPEC pricing behavior during the recent "oil glut" is more indicative of the cartel's resilience than its weakness. They believe that the price of oil is likely to be quite volatile and that there is a substantial probability that prices could be well above even the high DOE case. By the turn of the century prices could increase to $55 per barrel.[13/]

---

[12] H.F. Keplinger, "The Crisis in Energy Is Here Now!" World Oil, July 1986.

Conclusion

The United States has built its agricultural and industrial economic miracle on cheap and abundant energy. Petroleum because of its energy density, versatility as an industrial feedstock and ease of transportation has been the ideal fuel. U.S. petroleum supplies are being consumed faster than new discoveries are being made. Petroleum production could be uneconomical in the United States as early as 2005. Petroleum prices are expected to remain weak until late in this decade but could increase to $55 per barrel by 2000. This seems to imply that alternative renewable energy and industrial feedstocks should be explored now in order to have products and commercial processes ready when the higher energy prices arrive. Corn is already being exploited as a substitute for petroleum in the form of ethanol. The following chapter reviews some of the possible new uses for corn, many of which are direct or indirect substitutes for petroleum or its derivatives.

[13/] William W. Hogan and Paul N. Leiby, op. cit., p. E-2.

IV. POTENTIAL NEW USES

During the course of this research over 20 different potential new corn uses were identified and reviewed. Undoubtedly there are many more which we were not able to uncover. And there are clearly some which are being explored in secrecy by proprietary companies. For example, several large chemical and agribusiness companies were approached for information. All responded that company policy does not permit them to divulge that information.

The following are, therefore, a combination of inventions by individuals and publicly supported development. These should only be considered as indicative of the kinds of products which can and probably are being explored for corn utilization.

Highway Deicer

For a number of years highway researchers have been looking for deicers to replace salt which is highly corrosive and environmentally detrimental. One alternative which has been considered is calcium magnesium acetate (CMA). In 1982 the Federal Highway Administration initiated a program for the complete evaluation of CMA as an alternative deicer. A report published in Public Roads in March, 1984 summarized the preliminary results of that program.

The article indicated that the most feasible production method for CMA is to produce acetic acid from biomass-derived sugars and then react it with dolomitic lime - a relatively simple process. A research report completed by SRI International[14] evaluated three different feedstock alternatives for producing CMA: (1) from high glucose syrup by fermentation, (2) from purchased synthetic acetic acid and (3) from corn grain by hydrolisis and fermentation. Corn grain was identified to be the most favorable biomass feedstock in the tonnages projected to be required; high-glucose corn syrup was a slightly less favorable choice.

Using a price per bushel of $2.80 for the corn grain, the estimated cost of production of CMA was 18-19 cents per pound, (Table 4.1), or about 7-8 times the cost of road salt.

Table 4.1 -- Production Cost of CMA
(dollars per pound of CMA)

Cost Factors	Corn Grain	Glucose Syrup	Synthetic Acetic Acid
Materials and supplies	0.113	0.184	0.216
Labor	0.014	0.012	0.008
Purchased utilities and fuel	0.020	0.017	0.010
Fixed costs	0.009	0.009	0.006
Capital-related charges	0.060	0.047	0.033
Total	0.216	0.269	0.273
CMA	0.188	0.257	0.273
Feed byproduct	0.028	0.012	---

1 lb = 0.45 kg

---

[14] SRI International, Process Development for Production of Calcium Magnesium Acetate (CMA), Federal Highway Administration Research Report No. FHWA/RD-82/145, U.S. Dept. of Transportation, Washington, D.C., Phase I, March, 1983.

Preliminary results indicate that CMA has little deleterous effect on plants and animals and is considerably less corrosive to metals and highway construction materials than salt. The National Cooperative Highway Research Program made a $200,000 grant to a University of Washington researcher to conduct a two year evaluation of the environmental effects of CMA. That study should be completed in August, 1987. A researcher at the University of Oklahama has concluded that CMA is ten times less corrosive than salt.

Road deicing tests in several states under variable conditions seem to indicate that CMA performs as well as salt in eliminating ice and snow from roads and bridges.

An Iowa Department of Transportation employee has developed and successfully tested a process for coating sand with CMA to produce an even more effective deicer with improved traction characteristics. And the Chevron Company is marketing a branded deicer this winter.

Unfortunately CMA and CMA coated sand are considerably more expensive than common salt. It is estimated that CMA coated sand for example is about 10 times as expensive as salt. But that high initial cost could easily be offset by lower social costs and reduced replacement costs for vehicles, bridges, roadways and utility installations.

Research sponsored by the New York State Energy Research and Development Authority has discovered that it may to be possible to produce CMA more cheaply using ground corn cobs as a primary feedstock. An ongoing research project is aimed at direct conversion of corncobs and other waste biomass to CMA using calcium and magnesium tolerant bacteria from the Dead Sea. They believe it may be possible to produce CMA at a price of 12-14 cents per pound.

Coal De-Sulfurization Using Ethanol

The coal industry has been greatly affected by legislation on limits of allowable sulfur dioxide (SO_2) emissions. When coal is burned, the sulfur is converted to sulfur dioxide (SO_2) which, when discharged into the atmosphere, is thought to contribute to the formation of "acid rain." Coal burned now must not emit over 1.2 pounds of sulfur dioxide per million BTU. In addition, sulfur dioxide emissions will have to be reduced 90 percent from that of run-of-mine coal in newly constructed power plants. Methods which remove sulfur during or after coal combustion have received considerable attention and funding. A serious setback to such methods is they require the addition of flue gas scrubbers and/or significant modification of existing power plants.

"Carbon Monoxide-Ethanol Desulfurization of High Sulfur Coal" is a precombustion process using carbon monoxide and ethanol which yields a solid product that can be burned in existing power plants. The process was developed through research that began ten years ago at the Illinois State Geological Survey under Richard Shiley and at Southern Illinois University at Carbondale.

In the last year or two, significant advances have been made. By studying how to transform one sulfur mineral to another, and the desulfurization reactions in which they participate and catalyze, it was discovered that coal could be desulfurized using iron sulfides formed from the pyrite present in coal. It was found that iron-rich pyrrhotites will catalyze the removal of organically bound sulfur when treated with ethanol. Experiments on coals collected throughout Illinois have shown that the sulfur content can be reduced to federal emission compliance levels. One advantage of this process, in addition to yielding a low sulfur solid fuel, is that the by-products are also commercially useful to agriculture and through the production of herbicides and other products.

The removal of organic sulfur from coal requires 0.028 pounds of ethanol per pound of coal (based on a coal with 1.8% organic sulfur). The production of one pound of ethanol requires 0.06 bushels of corn. Based on an estimated 1984 Illinois coal production of 65 million tons, desulfurization would require 217 million bushels of corn.

Methanol Cetane Enhancer Using Corn Cobs

For many years diesel has been the cheapest source of liquid fuel. But the oil embargo awakened considerable interest in the development of alternative fuels to reduce dependence on foreign oil and to identify cheaper long term replacements for diesel. Moreover, diesel engines are efficient but dirty. The Environmental Protection Agency (EPA) has proposed strict limits on emissions from diesel engines to take effect in 1991. Methanol, which is now made from natural gas, costs slightly less than conventional petroleum-based diesel fuel. It is expected that methanol will continue to be less expensive than diesel fuel, perhaps substantially so by the middle of the next decade.

Much work has been done to identify ways to convert diesel engines to use methanol. But pure methanol has several disadvantages. Costly engine modifications are required in order to achieve proper ignition temperatures for methanol use in diesel engines . In addition, methanol tends to wear engine parts due to its lack of lubricity and viscosity.

The New York State Energy Research and Development Authority, in cooperation with the Ontario Ministry of Energy, Imperial Oil, Ltd., Cummins Engine Company, Inc. and others have been supporting research to develop and test an additive which promotes ignition of methanol in diesel engines. The intended feedstocks for the process were lignin derived from wood and peat, both of which are found in abundance in New York and Ontario.

The research has been contracted to Dr. Gustav Schulz of the University of Pittsburgh Applied Research Center who developed the basic process using coal while employed by Gulf Oil Company. Over several years of research, Schulz discovered that younger coals were easier to solubilize and concluded that biomass materials should work better than coal. In Schulz's process, coal or a biomass feedstock, pulverized to a mesh size of about 10, is slurried with an equal weight of water and heated to about 50 degrees centigrade. Concentrated nitric acid is added, care being taken that the heat generated is dissipated to prevent the slurry from becoming too hot. When the reaction is completed, excess acid is removed by a simple additional step.[15/]

During the course of the research, which was initiated in April, 1986, several alternative sources of lignin material have been used to produce a cetane enhancer using the Schulz process. Tests of the resulting materials are still in progress, but a test mixture of 79 percent methanol, 20 percent lignin derived octane enhancer and 1 percent castor oil was able to start a test diesel engine, a significant achievement.

But the most exciting development from the standpoint of corn growers, came about when a supplier of lignin accidentally sent lignin derived from corn cobs instead of lignin from wood waste products as intended. The material was tested and appears to have advantages over other feedstocks. Researchers then tried using finely ground whole corn cobs. The preliminary results were surprising; about 65 percent of the material was directly soluble in methanol using the Schulz process. The remaining solids appear to be high quality cellulose materials which have not yet been analyzed. If the material is found to be high in alpha cellulose, the by product could be worth as much as $800 per ton. Furthermore, Dr. Schulz, in a personal interview commented that the

---

[15/] "Process Yields Diesel-Like Fuel From Coal, Peat, Biomass", C&EN, July 1, 1985 process is extremely simple and straight forward. It may well lend itself to relatively small scale, low investment production facilities which would have to be located near the source of corn cobs to minimize transportation costs.

Additional tests are to be conducted in the next few months using several different feedstocks, including corn cob lignin and whole ground cobs. Diesel engine tests of the material will be conducted under controlled conditions at the Cummins Research Center. Many technical questions remain to be answered, A first approximation of production costs and possibility economic viability will be completed by November, 1986. Preliminary cost estimates indicate that the cetane enhancer might be produced for about half the cost of methanol which has generally been competitive with diesel prices on a cost per million BTU basis. Commercial methanol production is already a reality with about 1 billion gallons produced last year using natural gas as a feedstock.

Some highly speculative assumptions give an indication of the possible economic implications for corn growers. If we assume that 1 billion gallons of methanol were blended with 200 million gallons of a cetane enhancer derived from whole ground corn cobs assuming a 65 percent methanol solubility of the material, then a brand new market for 490 thousand tons of corn cobs would suddenly materialize. The market price for that new feedstock would be determined by production costs and market acceptance. The important point is that whatever the price, it would represent an entirely new source of additional revenue for corn growers.

Fuel Slurries from Corn Wastes

A number of current R&D products are demonstrating that slurries of bituminous coals in water can give acceptable performance in diesel engines, except for the high abrasiveness of the ash components in the coal, using 10-20% diesel oil for pilot fuel. Three years of research at University of North Dakota Energy Research Center (UNDERC) have demonstrated that hydrothermally upgraded lignite slurries have equal or better combustion characteristics. Preliminary tests with peat and sawdust indicate that equally reactive (quick burning) fuels may be produced by applying this technique to waste biomass, which offers the advantages of very low ash levels, making it an attractive engine fuel. Some minor admixture of a liquid or vapor pilot fuel is essential to promote ignition in an engine. The use of ethanol for this purpose offers the advantage that it is completely miscible in the slurry, keeping it from freezing. UNDERC is beginning a program of developing coal-water slurries for testing as diesel fuels. The same technology and facilities can produce biomass-water-ethanol slurries that can be tested on the premises.

Preliminary estimates indicate that the potential biomass-water-ethanol slurry should be producible at a cost comparable to or lower than the diesel fuel it could replace. A recent study of the UND hot-water-drying process, by Bechtel

Corporation, indicates that a lignite slurry fuel could be produced for $1.40/MMBtu. This assumed lignite available at $11.00/ton to a plant size of 7,500,000 ton/yr. Ignoring production scale for the moment, let us assume that a farm waste product, such as corn stalks, could be collected at the plant site for about the same cost and used to produce a slurry fuel of only 5,000 Btu/lb, with about the same density as water, giving a cost $.0595/gallon. Diesel fuel has about 19,00 Btu/gallon and presently sells for about $0.72/gallon for off-road use. Thus it will take 3.9 gallons of such a slurry to replace each gallon of diesel, at a cost of $0.23 per equivalent gallon of diesel. From a more general study by Davy-McKee, economic scale factors indicate that if such a plant were scaled down to 1,000,000 tons/yr, the product cost would rise to only $0.273 per equivalent gallon of diesel. Clearly, this product can be blended with a substantial amount of ethanol at $1.25/gallon and still be considerably cheaper than diesel fuel.

The major attraction of this potential new product is that it would use substantial amounts of ethanol produced from corn to substitute for diesel fuel while providing, for the first time, a market for corn stalks.

Modified Corn Starch for Wound Treatment

Approximately 3 million Americans suffer from pressure ulcers (bed sores) at any given time. Most are confined to hospitals, nursing homes or other institutions and are economically disadvantaged. A low cost and effective treatment has never been available. Similarly, treatment for severe burns, which are a major medical problem, has never been as effective as desired.

Dr. Anthony N. Silvetti, a medical researcher in Chicago has been experimenting with the use of a modified corn starch in the treatment of bed sores and burns. He has experimentally treated over 1600 patients with remarkable results. During a personal interview he showed numerous slides documenting before and after treatment with nothing more than the modified corn starch several times a day. In addition, we were able to personally observe the effects of the product on several patients with severe wounds. In some cases the bed sores were healed even after the wound had progressed all the way to the bone.

Dr. Silvetti believes that the modified corn starch somehow assists the body in regenerating skin tissues. Heretofore, severe skin and deep flesh wounds could only be treated with skin grafts, an expensive procedure.

Dr. Silvetti is anxious to obtain corroborating research from other independent medical installations around the country. He has applied for product approval by the Food and Drug Administration. That final approval cannot be obtained until adequate objective evidence is ;resented to confirm the product's effectiveness.

Corn Stillage As An Adhesive/Binder

University of Nebraska researchers have developed a process for using stillage from ethanol plants as a binder for producing composite board building materials and for producing energy cubes from solid waste.

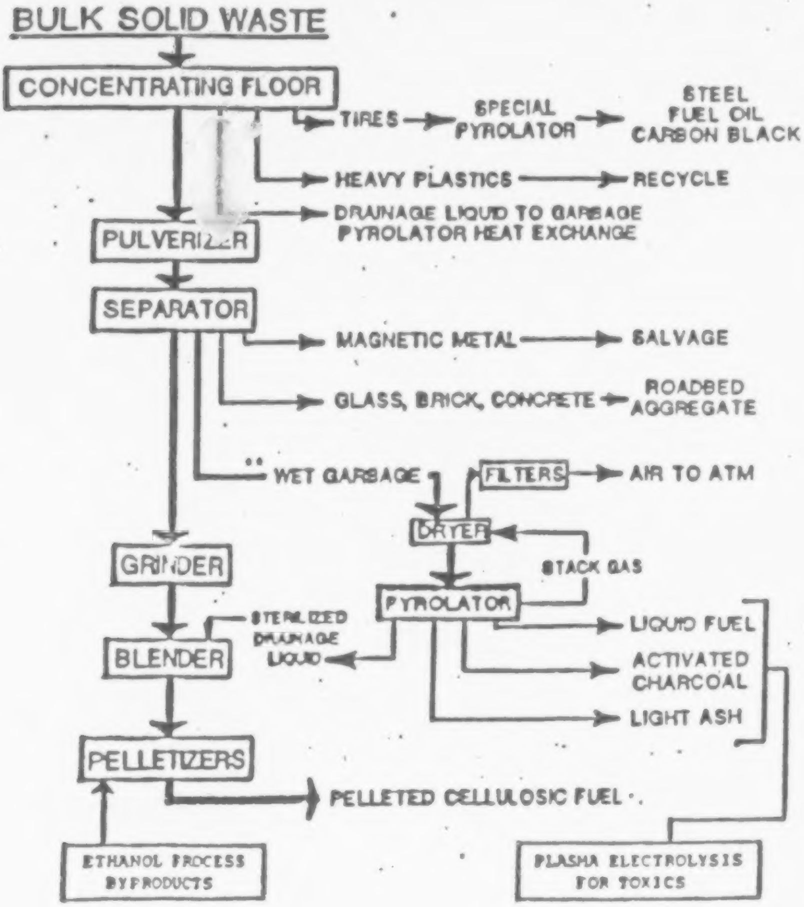
In the case of composite board from wood chips the process would be to spray stillage treated with a chemical "initiator" onto wood chips. The entire mass is placed in a press under appropriate heat to produce the desired product. During the week of May 20, University representatives spent two days at a Borden company research facility on the West coast testing the process. Results should be available in the near future.

In the case of energy cubes from municipal solid wastes the process is described in the attached schematic.

Figure 4.1 depicts the basic characteristics of the MSW system. The city of Lincoln's solid waste will be delivered to the processing center to be processed for maximum recovery. Items like glass, metals, plastics and aluminum or oversized items will be removed. Processing as per Figure 4.2 will be carried out. One possible scenario is that forty percent of the total carbon based MSW could be made into fuel cubes which can be used in gasification or in a variety of boilers in the area. An additional forty percent could be composted to recover the fertilizer value and soil amendment properties of humus. Ten percent of the total is projected to be recovered as traditional recyclables and a maximum of ten percent of the most difficult materials may go directly to the landfill.

FIGURE 4.1

LINCOLN MSW MATERIAL FLOW


BULK SOLID WASTE
CONCENTRATING FLOOR
TIRES
SPECIAL PYROLATOR
STEEL
FUEL OIL
CARBON BLACK
HEAVY PLASTICS
RECYCLE
DRAINAGE LIQUID TO GARBAGE PYROLATOR HEAT EXCHANGE
PULVERIZER
SEPARATOR
MAGNETIC METAL
SALVAGE
GLASS, BRICK, CONCRETE
ROADBED AGGREGATE
** WET GARBAGE
FILTERS
AIR TO ATM
DRYER
STACK GAS
GRINDER
PYROLATOR
STERILIZED DRAINAGE LIQUID
BLENDER
LIQUID FUEL
ACTIVATED CHARCOAL
LIGHT ASH
PELLETIZERS
PELLETED CELLULOSIC FUEL
ETHANOL PROCESS BYPRODUCTS
PLASMA ELECTROLYSIS FOR TOXICS

** Wet garbage can alternatively go to a composting operation depending on local economics.

6b-62.

Solid waste disposal is becoming a major environmental problem all over the United States. Iowa appears likely to pass a law requiring municipalities to gradually eliminate landfills - by 1997, substituting alternative methods of solid waste disposal. However, most experts agree that no clearly economical alternatives have yet been developed.

A working group has been established to apply the process developed at the University of Nebraska in the treatment of the solid waste for the city of Lincoln, Nebraska. The group proposes to set up a private company.

While the basic process has been described a certain amount of research and development remains before an efficient commercial operation can be started. The leader of the working group, John Eastin of Kamterter, Inc. estimates that approximately $300,000 would be required to carry out all preliminaries required to get to the point where a commercial operation could be set off. The following is a rough breakdown of those costs:

Project Manager-Developer	$ 50,000
2 University Researchers	100,000
Feasibility Study/Business Plan	75,000
Engineering Designs	50,000
Finance/Promotional Costs	25,000

The working group includes the University of Nebraska, which has accepted the principle of equity in the proposed company in exchange for its patent rights and overhead costs on research carried out in support of the venture. The working group has indicated a desire to explore the possibility of the National Corn Growers Association making a cash contribution towards the above development costs in exchange for equity in the proposed company.

Bio-Degradable Plastics from Corn Starch

The United States produces more than 30 billion pounds of plastics each year. Virtually all of this plastic is made from petroleum-based raw materials. Rapidly increasing prices, dwindling supplies of petroleum, and the need for biodegradable plastics have intensified interest in natural products as alternate sources of raw materials for making plastics. Starch, especially from corn, is probably the most abundant and lowest cost natural polymer available and its use in plastics production would greatly reduce the demand for petrochemicals and the negative impact on the environment now caused by discarding plastics that do not biodegrade.

Farmers especially need degradable plastic items, including mulch, coatings for the controlled release of herbicides and insecticides, seedling containers, films for protecting roots during transplanting, and containers for toxic agricultural chemicals. Approximately 140 million lb. of polyethylene (PE) film is used annually in the U.S. as mulch to improve crop yields 50 to 350% by controlling weeds, retaining soil moisture, and reducing nutrient leaching .

Since polyethelene film for mulch cannot be reused and does not degrade between growing seasons, it must be removed from the field and disposed of at an estimated cost of $100 per acre. Hence the development of a biodegradable film for mulch application would significantly benefit agricultural technology.

Since starch alone forms a brittle film that is sensitive to water, it is generally understood that starch must be combined with other materials in order to produce a satisfactory film. Polyethelene is the most widely used material for producing films that have desirable physical properties for packaging and mulch applications, and it is available at a relatively low cost. It is, therefore, a particularly desirable material to combine with starch to achieve the desired flexibility, strength, and water resistance.

The Northern Regional Research Lab of the USDA has developed and patented a process for producing a biodegradable plastic from corn starch. Further research and engineering is needed to determine the commercial feasibility of the process. Several companies have shown interest in the patent. One group of investors has initiated the start up of a new company to produce products using the process. It appears that an early application of the process could be the production of a biodegradable plastic film for mulch in the production of certain agricultural products. Plastic films produced from non biodegradable petroleum materials are currently used extensively in some areas for several vegetables and berries. Other probable uses for the biodegradable plastic are:

Garbage bags
Plastic plates
Degradeable seed coats
Pesticide coatings
Degradeable mulch
Plastic cups
Plastic films of many types
Bottles and jugs
Fertilizer coatings

The following table shows production estimates for the different types of plastics.

An overview of plastics production in the U.S.
(Production of the five leading thermoplastics in 1984
was over 31 billion pounds)

Types of Plastics in order of usage	Production	Value
1) Low density polyethelyene	8.5 bil. lbs.	$3.4 Bil.
2) Polyvinyl chloride	7.0 bil. lbs.	$2.5 Bil.
3) High density polyethylene	6.0 bil. lbs.	$2.4 Bil.
4) Polypropylene	4.8 bil. lbs.	$2.0 Bil.
5) Polystyrene	3.9 bil. lbs.	$1.6 Bil.

Corn starch is a renewable resource available from the plant that is the most efficient plant we have for converting the sun's energy into a usable form.

Full replacement of the low density polyethylene film by a starch/polyethelene blend would result in the need to convert approximately 320 million bushels of corn per year to starch.

In many of the above applications, the corn starch based plastic will not be used in entirely new products, but will simply replace more costly and less effective plastics which are currently made from petroleum based plastics. We estimate that corn starch based plastics might be able to replace from 30 to 45 percent of the low density polyethelene plastics producing an additional market for about 112 million bushels of corn per year.

Grafting Cellusosic Polymers To Synthetic Plastic Polymers

The Polymer industry has always relied heavily on blends to combine different materials to achieve desired material qualities. But a physical blend can only be done with compatible materials. It is just that, a blending together of two different compatible materials. However, cellulose and synthetic fibers are not compatible. Efforts to blend the two yield a product which will not stick together - or which is very unstable and unpredictable.

Dr. Ramani Narayan has developed a technique called graft copolymerization using anionic polymerization. He introduces a third polymer compatible with two others which are not compatible with each other. That polymer chemically links itself to each of the others, forming a stable bonding of all three polymers. The following is a technically more accurate description of the process taken from a research proposal prepared by Dr. Narayan.

> We have recently described a new method (5,6) for the preparation of cellulosic graft polymers involving anionic polymerization techniques that would overcome the drawbacks of the radical polymerization methods. The method involves (1) preparation of the living synthetic polymer of desired molecular weight by anionic polymerization, (2) introduction of electrophilic groups or leaving groups onto the cellulose backbone by chemical modification, (3) reaction of the living synthetic polymer with the modified cellulose. If the cellulose derivative is soluble in an organic solvent, then an additional advantage of the new method is that the coupling reaction between the modified cellulose and the living polymer can be carried out under homogeneous conditions.

Dr. Narayan is planning to apply this new technique to the graft polymerization of corn gluten feed (dried soluble by-product of wet milling) with polystyrenes (e.g. styro-foam). He believes the resulting product would have many of the characteristics of polystyrene but the stronger cellulose could produce some very desirable additional properties. The product should also be cheaper since dried gluten solids are less expensive than synthetic polystyrene feedstock.

It is possible that if one could plasticize the corn by-product material, then one could conceivably process and fabricate this material similar to the styrene plastics for a host of applications like packaging, appliances, housewares, furnishing, recreating, service ware, etc. The plasticization of the corn by-product can be achieved by grafting polystyrene or similar thermoplastic material using the approach described above. Another approach which may be more cost effective and practicable would be to prepare a blend of the corn by-product with polystyrene or any other thermal plastic together with a certain percentage of the graft cellulose-polystyrene copolymer. The cellulosic graft polymer would act as a compatibilizer and allow the preparation of a stable, easily processable blend with good physical and chemical properties. A mere physical blend of polystyrene with the corn by-product would be very unstable with very poor physical properties due to the inherent incompatibilities. The structure of the graft copolymer will exert a strong influence on the physical properties of the new material. Thus, one would have to actually prepare graft copolymers of known structure, i.e., known molecular weight, point of attachment, degree of substitution, etc. This is possible only with the new methodology being developed by Dr. Narayan.

Dr. Narayan has recently received a National Science Foundation (NSF) grant to support this proposed research. However, he will not be able to produce actual product since he does not have access to the appropriate extrusion equipment. The NSF grant is for 2 years.

Whey/Corn Slurry as Ethanol Feedstock

In a meeting with Paul Whalen of the Food Science Department at the University of Nebraska, it was learned that lab research and pilot plant applications have confirmed that a process developed by Dr. Kim Shahani and his student Paul Whalen can produce ethanol using whey and corn at costs of about 18 cents per gallon less than ethanol from whole corn. The University of Nebraska has applied for a patent on the process.

Whey is a by-product of cheese production generated at a rate of about 9 kg for every 1 kg of cheese or 61 kg for every 1 kg of cottage cheese. Whey consists of approximately 5% lactose, 0.9% protein, 0.3% fat, and 0.5% ash depending on the source (Nickerson, 1974). In the U.S. about 21 billion kilograms of whey were produced in 1983 of which only 50% was further processed into various whey products (Whey Products Institute, 1984). The remaining 10.5 billion kilograms were dumped or otherwise treated as waste. Whey has a biochemical oxygen demand (BOD) of 35 -

45,000 ppm and is one of the most potent of wastes (Singh et al., 1983; Jelen, 1979). One hundred kilograms of whey are equivalent to the sewage produced by 45 people (Jelen, 1979). At this rate a medium sized cheese plant discharging 50 - 150 x 10^3 kg of whey/day (Modler, 1982) constitutes a polluting strength equal to the sewage from 22,500 to 67,500 people on a daily basis. Therefore, the surcharge for discharging whey into municipal systems becomes a major expense to the cheese producer.

The process involves using whey as the liquid portion of the corn mash. Figure 4.3 shows the process flow for whey - corn cofermentation.

The significance of this discovery is that small to medium sized cheese plants who currently face major problems and costs for whey disposal now have the option of utilizing whey in co-fermentation with corn for ethanol production. Assuming zero cost for the whey, researchers have concluded that ethanol costs would be reduced by 18 cents per gallon in comparison to ethanol produced from corn alone.

In most cases cheese plants must pay some fee to get rid of the whey. It is therefore reasonable to assume that the product could be obtained without charge to the ethanol producer. However, except in rare cases where ethanol and cheese plants were located at the same site, there would be transportation costs to move the whey to ethanol sites. No analysis of those transport costs has been done. But to produce 3 liters of mash 2.6 liters of whey are required over only 541 grams of corn. This seems to suggest that

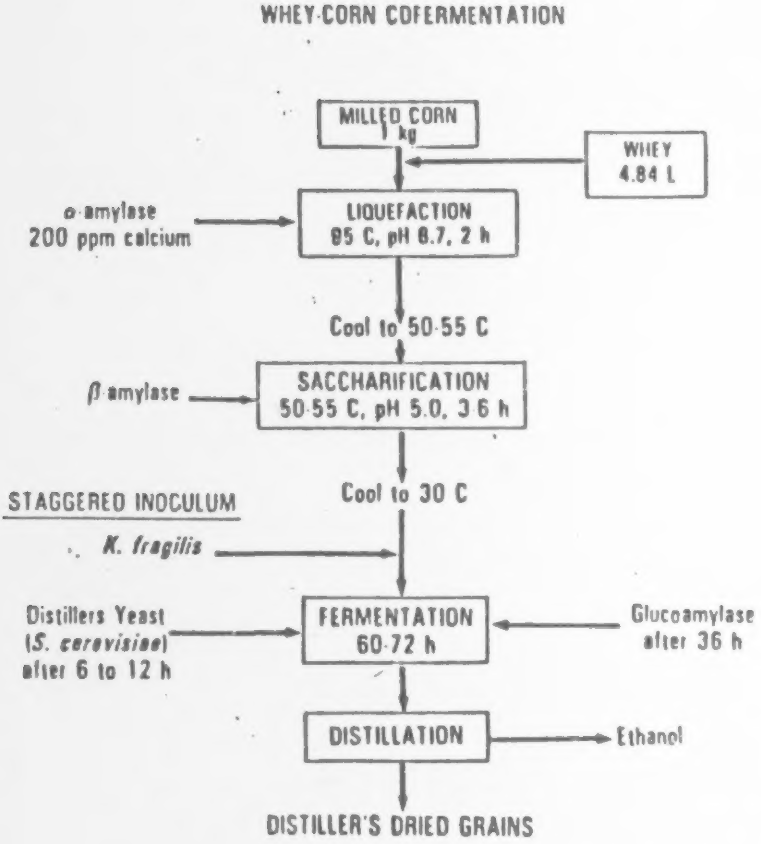

WHEY-CORN COFERMENTATION
MILLED CORN 1 kg
WHEY 4.84 L
α-amylase 200 ppm calcium
LIQUEFACTION 95 C, pH 6.7, 2 h
Cool to 50-55 C
β-amylase
SACCHARIFICATION 50-55 C, pH 5.0, 3-6 h
Cool to 30 C
STAGGERED INOCULUM
K. fragilis
Distillers Yeast (S. cerevisiae) after 6 to 12 h
FERMENTATION 60-72 h
Glucoamylase after 36 h
DISTILLATION
Ethanol
DISTILLER'S DRIED GRAINS

Fig. 1 Process Flow Scheme for Whey/Corn Conversion and Fermentation.

it would be advantageous to locate whey-corn co-fermentation plants near cheese plants. A ten million gallon per year ethanol plant would require about 2.2 million gallons of whey per week. A medium sized cheese plant will produce about 750,000 gallons of whey per day. Thus, three medium sized cheese plants would be needed to supply a single medium sized ethanol plant.

Tentative Conclusion

This technology could marginally increase the use of corn for ethanol production by reducing ethanol production costs in those cases where sufficient concentrations of whey can be made available to a nearby ethanol plant. An estimate of the impact of this technology on corn usage for ethanol will require an analysis of cheese plant and ethanol plant locations using linear programming methods.

Starch Encapsulation of Pesticides and Pharmaceutical Products

The Northern Regional Research Lab has also developed and patented a process for coating materials to assure uniform release of active ingredients and to protect against undesired reactions during distribution and application of pesticides and pharmaceutical products. Interviews with researchers at the Lab produced detailed information on the process and indicated that at least four companies have applied for licences under the patent.

Super Absorbent Materials From Corn Starch

During the 1970's the researchers at the Northern Regional Research Lab developed a process for producing a super slurper which can absorb 1000 times its weight in moisture. Three companies are currently licensed under the USDA patent to commercially produce and market the product. The product is already moving into the marketplace in diapers, treatment of burns and wounds, the coating of seeds to accelerate germination and increase yields, the coating of roots of trees and other plants that are to be transplanted, the elimination of water from fuel tanks and the treatment of soils to increase their water holding capacity.

Several articles have appeared in horticultural and gardening publications touting the product for some of the plant improvement applications. It seems that for many uses the cost effectiveness has already been established. But literally hundreds of potential uses could be exploited. The following is a partial listing:

Medical

(absorption of body fluids -- blood, urine, saliva, and perspiration

- catamenials
- disposable diapers
- bandages
- incontinent pads
- surgical gowns
- surgical sponges
- bed pans
- foot cushions and pads
- gloves (welding, etc., heavy asbestos)
- cosmetics, lotions
- tablet disintegrant
- powders -- hand, body
- dental rolls

Agricultural--Horticultural

seed coatings,
root coatings
soil additive
hydroseeding
seed pelletizing
pesticide formulations (retain water to improve efficiency)
drip irrigation (place in irrigation water to deliver gel or swollen particle to soil)
cut flowers
retain moisture during shipping of flower and vegetable plants
agricultural sprays--dispersing or suspending agent
animal bedding and pet litter

Thickening-Dispersing-Solidifying Agent

firefighting fluids
textile print pastes
radioactive wastes (solidification)
sludge (solidification)
athletic fields (remove excess water)
construction sites (remove excess water)
basements (remove excess water)
household products (waxes, polish, paints)
agar substitute (microorganism cultures, insect-growing media, tissue culture)
organic-water systems (must make amine salt rather than sodium or potassium; use thickening paint strippers)
drilling muds and other petroleum applications

Water Removal from Other Liquids

water-oil emulsions
solvents
oil

Binder

foundry core binder (green strength)
pelletizing iron ore
charcoal briquettes

Paper and Textiles

absorbent paper towels and tissues
moisture retention in synthetic textiles as antistatic agent
water retention aid in hardboard manufacture

Concentrate Proteins and Other Polymers

remove water from polymeric materials

Toys and Novelties

Foods and Feeds
(many applications, but require FDA approval in this country)

Granulated Synthetic Rubber Using Corn Starch

Department of Agriculture researchers have succeeded in producing powdered rubbers with cheap materials and an inexpensive process. The powdered elastomers consist of latex particles encased in starch derivatives that serve as rubber reinforcing agents. The materials -- starch, water, sodium hydroxide, and carbon disulfide, all costing several times less than any general purpose rubbers -- are used to make a starch xanthate solution, which is added in small quantities to latex to produce a fine crumb or powder. The starch xanthate encasement is said not to affect either the properties or performance of the rubber, but provides a powder that easily adapts to automatic weighing and handling systems and that requires substantially less power than conventional forms of rubber to prepare compounded stocks. The procedure has been thoroughly and successfully tested with emulsion polymerization systems. Evidence suggests that powdered rubber can be produced more cheaply than slab or crumb rubber.

Corn starch, the chief additive in this technology, is sufficiently inexpensive to keep production costs competitive with other rubber production technologies. This new use would provide a substantial new market for corn starch.

Unfortunately the patent for this process has been registered for several years and the process has not been adopted in the industry. One knowledgeable source indicates that while manufacturers using synthetic rubbers prefer the convenience and lower cost of powdered rubber, their significant capital investment in old technology using slab rubber, makes it difficult to switch to the new process. This is especially true for tire manufacturers who have faced several years of highly competitive and unprofitable operation.

Corn Protein Textile Fiber

Zein is an odorless, nontoxic protein derived from corn. It is a by-product of corn processing, and it is made into a vegetable protein fiber, primarily used in blends.

The Virginia-Carolina Chemical Corporation did extensive industrial research on it, and in 1948 began to manufacture a zein fiber under the trade name Vicara. A large fiber plant in Taftville, Connecticut was purchased and retooled, and the fiber brought into commercial production.

In producing Vicara, powdered zein is mixed with a caustic solution until complete suspension is secured. This solution is allowed to age until the proper viscosity is obtained. The spin solution is then extruded through spinnerets with thousands of holes, producing a great number of filaments, which are combined into a tow containing as many as 270,000 filaments.

The spin solution is passed through an acid coagulation bath which hardens the protein molecule and separates it from its alkaline solution. The tow is cured and then exposed to a series of stretching and orientation processes which align the molecules, resulting in a stronger filament or fiber. Upon stretching the tow is dehydrated to prevent shrinkage after stretching. It undergoes a subsequent curing operation and is washed with large amounts of water to free it from acids and salts. It is then dried and finished and, if desired, cut into uniform staple lengths and baled.

Vicara is produced as an extremely soft, uniform fiber, light golden in color, being manufactured either bleached or unbleached. The fiber has warmth equal to wool. Its insulating value is similar to that of animal fibers in a fabric of like construction.

Vicara may be had as water repellent as wool. The water repellency is permanent at room temperature and is not removed by dry cleaning or repeated laundering. It is less flammable than the cellulosic fibers. Vicara is not seriously affected by temperatures up to 350° F., and the melting point is reached at 470° - 475° F.

Vicara resists acids and has an affinity for most dyes. Because of Vicara's resistance to most chemicals, acids, or alkalis, and its stability at high temperatures, no caution is necessary in laundering and ironing.

Because of its great versatility Vicara is used chiefly in blends with other fibers. When blended with wool Vicara upgrades the finished product and increases the wear life of these fabrics by enabling them to wear without pilling, stringing, or fraying, making these blends ideal for women's and men's suitings and outerwear. In blends with cotton, Vicara adds drape, softness, elasticity, mildew resistance, and a better hand and feel.

Vicara has many properties that are similar to wool (it is possible to secure a woollike feel): nevertheless it has many other fine properties of its own and under no circumstances should be considered as a substitute for any other fiber. It poses no difficulties in spinning and weaving as it can be used on any commercial machinery today; i.e., that for worsted and woolens, or the Bradford, French, rayon, and cotton systems.

In spite of its apparent attractive characteristics Vicara production was suspended by the Virginia-Carolina Chemical Corporation after a relatively brief period. We have not yet been able to determine what reasons motivated the decision. It appears that the fiber was relatively more expensive than the numerous synthetic fibers which were produced from cheap ($2-6 per barrel) petroleum which were flooding the market in the post World War II period.

Self-Cooling Cans

Laser Arms Corp. (OTC) announced it has unveiled a technology that it claims "will chill the world population by the year 2000.

The technology provides an ordinary can with the ability to refrigerate itself upon opening. A Food and Drug Administration-approved aluminum sheath runs the length of the beverage container and is attached to the container on the inside top. The sheath is filled with cabron dioxide that is released through a controlled release valve located at the container top. As the tab to the container is pulled, a puncture pin penetrates the top of the sheath releasing the Carbon Dioxide. As the CO_2 is released the aluminum sheath freezes which in turn chills the contents of the container. The cost of the process is less than 2 cents per can, with a displacement-of-liquid factor of 2.5 ounces.

The self chilling can technology is protected under 17 patents issued and several pending in the following countries: United States, France, United Kingdom, Germany, Japan, Austria and Canada.

U.S. Consumers use 300 million beverage cans daily -- while worldwide the consumption is over 1 billion cans per day. It is estimated that five billion chill cans will be in consumers hands by the turn of the century. If this new process proves economical sizable quantities of carbon dioxide would be required. At present large amounts of carbon dioxide are produced as by products of the ethanol from corn production process. Carbon dioxide uses are limited so large quantities remain unsold.

Unfortunately we have not been able to reach officials to obtain further information beyond that which appeared in a paid Wall Street Journal advertisement in May, 1986.

V. ANALYSIS OF THE MOST PROMISING NEW USES

Many of the potential new uses described in the last chapter are in the very early stages of research and development. In many cases, additional basic and/or applied research is necessary even before one can assess the market potential and possible benefits to corn growers. In most cases, additional laboratory and bench scale research is necessary before pilot scale process engineering can be undertaken.

In this chapter we have chosen those opportunities with the highest likelihood of success in the relatively near term. We must stress, however, that even under the best circumstances corn growers are not likely to see additional corn used by these processes in less than 3 years. But in most cases the long term usage could be substantial.

Calcium Magnesium Acetate as a Highway Deicer

Every winter snowbelt states and cities are faced with the challenge of keeping roads clear and safe so that economic activity can proceed without major disruptions. Most jurisdictions have adopted the practice of using rock salt as a melting agent to facilitate snow removal and to keep pavements bare and safe. Salt has proven to be the least expensive and most effective material available. Every year close to 10 million tons are consumed for highway deicing. But as the quantity of use has gone up it's major disadvantages have become more visible. It is highly corrosive to bridges and other steel structures, it is corrosive to automobiles, it causes damage to road surfaces, it is harmful to roadside vegetation and it permanently damages water supplies. The Federal Highway Administration and many state and local highway authorities have become increasingly concerned about these detrimental effects. Many jurisdictions have undertaken to dramatically reduce the amount of salt applied. But there are no commercially available alternatives which are anything like as effective or as cheap as salt.

Background of CMA

The most logical alternative to salt is calcium magnesium acetate (CMA). In 1982 the Federal Highway Administration decided to undertake a major research effort to "develop methods for economically producing CMA, to determine its environmental acceptability and technical merits, and to develop warrants for its use." Since that time several million dollars of federal and state funding have been used to complete the following tasks related to CMA use as a deicer:

(1) determine environmental acceptability, including analysis of its corrosive effects, analysis of its effects on animal and plant life and its effects on water supplies;

(2) development of manufacturing technology, including laboratory and pilot scale production of materials for field testing and analysis of most economical production methods;

(3) technical and economic evaluation of ice melting abilities, corrosive effects, optimum application rates and cost analysis.

Most of the studies are now complete and everything indicates that CMA performs as well as salt but is 10 times less corrosive, has little detrimental effect on vegetation and wildlife and does not lower water quality for human consumption (see Annex I). However, the material's major drawback is the fact that it costs about ten times as much as salt. Production cost studies indicated a range of 18 to 28 cents per pound depending on the cost of feedstocks used in the production process.

CMA can be produced using a relatively simple and straight forward chemical reaction of acetic acid (vinegar) and dolomitic limestone or dolime. Acetic acid can be produced by chemical reactions using petroleum feedstocks or by fermentation using different types of starch or biomass. The Federal Highway Administration studies indicated that the least cost method would be the fermentation of corn grain. The study, which was done by SRI, International, concluded that the cost of CMA assuming corn prices of $2.80 per bushel would be about 19 cents per pound.[16/] At current corn prices of $1.60 per bushel the cost would be about 11 cents per pound.

At the present time there are no large commercial producers of CMA for deicing. However, several companies have done experimental production and one (Chevron's Ortho Division) is aggressively test marketing a branded product called "Ice-B-Gon". (See Annex II for a copy of their promotional literature.) The test products are being produced in the company's Ft. Madison, Iowa plant using synthetic acetic acid for the time being.

There are no large commercial producers of acetic acid from corn. The process identified by SRI, International appears to be fairly straight forward but no corroborative laboratory research or pilot production has been undertaken using the process. There is still some doubt as to the optimum bacterial strain to use in the process and as to the best commercial source of that bacteria.

Current Applied Research

Ongoing research sponsored by the New York State Energy Research and Development Authority, Chevron and others is focused on the possibility of producing CMA from a direct continuous flow fermentation process using waste biomass feedstocks with the limestone incorporated simultaneously. They are shooting for a production cost of finished CMA of 12-14 cents per pound. That price is considered low enough to permit market penetration.

Interviews with Chevron's project manager, Mr. Dan Walters, indicate that the company is quite excited about the possibility of

---

[16/] SRI, International, op. cit. p. 40.

being able to produce a product at their Ft. Madison, Iowa facility using abundant nearby corn as a major feedstock and supplying CMA to nearby states for deicing. He points out that the steps to commercialization are:

(1) corroborative laboratory testing of the corn to acetic acid process;

(2) significant market testing of their current CMA products to perfect product quality and determine recommended usage rates;

(3) pilot scale testing of the corn to acetic acid process and to establish process engineering parameters and cost estimates;

(4) economic and financial feasibility analysis;

(5) financing arrangements;

(6) plant construction and shakedown.

Completion of all of the above would take at least 3 and probably 4 years.

Chevron is currently negotiating with the NYSERDA led consortium to participate in funding the research on acetic acid production from biomass waste. Phase I, laboratory and bench scale work on production processes, is currently underway at Dynatech and should be completed by April, 1987. Phase II, pilot scale plant design and testing, is scheduled to begin in May, 1987 and will take at least one year. Funding and related arrangements are currently being discussed. It may be possible to arrange to expand that research to "add on" research on conversion of corn grain. Chevron is certainly supportive of that idea.

Chevron is currently negotiating with several states (California, Iowa, New York, Massachusetts among others) to supply their branded CMA product, "Ice-B-Gon", in 200 ton or larger quantities for testing this winter. A major test of several thousand tons of CMA in a single state would be ideal in terms of providing sufficient experience under different conditions to prove the product's effectiveness, to accumulate experience with appropriate application rates, to evaluate the use of conventional salt spreading equipment with the product and to observe it's impact on the environment. Iowa, a state which has already had considerable experience with the product, is a logical choice. Chevron has held discussions with the Iowa Department of Transportation but the decision is still uncertain. Senator Tom Harkin has also been urging the Iowa Department of Transportation to move toward the use of CMA even though he was not even aware that it could be produced from Iowa corn. His major concern has been the detrimental environmental impact of salt.

Chevron is anxious to work with the National Corn Growers Association to explore the possibility of mutual assistance in determining the feasibility of using corn to produce CMA. It seems clear that the company is seriously committed to marketing a CMA deicer and are willing to be convinced that corn is an economical feedstock. They are prepared and capable of making a substantial investment in production facilities once they are satisfied that a sizable market can be developed and when the profitability is confirmed.

Potential Corn Usage

Interviews with numerous federal and state highway officials and a review of studies on the environmental impact of heavy road salting practices indicates that CMA will capture some share of the deicer market in the next few years. A knowledgeable federal highway official estimates that CMA will capture at least 10 percent of the deicer market. Since recent annual highway salt usage has been about 10 million tons the potential market could easily be 1 million tons of CMA. Table V.1 shows estimated salt usage in some of the major snowbelt states. Many are also major corn producing states.

TABLE V.1

Estimates of Annual Deicing Salt Consumption

CALIF	4,627	NH	133,743
CONN	77,165	NJ	104,351
D.C.	21,000	NY	764,506
ILL	475,341	NC	42,691
IND	280,342	OHIO	668,565
IOWA	73,895	PENN	563,376
KS	39,526	RI	43,526
MAINE	72,918	TENN	44,517
MD	138,359	UTAH	94,735
MASS	255,879	VT	84,749
MICH	638,423	VA	163,433
MINN	181,521	WVA	186,694
MISSOURI	190,679	WISC	336,384
NEB	26,274		

SOURCE: The Salt Institute

To produce a ton of CMA, would require 60 bushels of corn using the process identified by SRI in their Federal Highway Administration sponsored research. One million tons of CMA would, therefore, require 60 million bushels of corn. If CMA replaced all road salt the annual consumption of corn would be 600 million bushels.

The SRI study also indicated that an economical size plant would produce 500 tons of CMA per day. Assuming 300 production days per year, each such plant would produce about 150,000 tons of CMA and use 9 million bushels of corn per year. The plant would also produce 45,000 tons of high protein feed, essentially distillers dried grains.

Some of the major corn belt states use several hundred thousand tons of salt per year (Table V.1). Illinois, for example, uses nearly 500,000 tons of salt per year. To replace all of that salt with CMA would require 3 of the 500 ton per day plants, each generating local employment and providing a market at the plant for 9 million bushels of corn per year.

Social Benefits of CMA

As noted earlier CMA is significantly more expensive than salt, probably 8 to 9 times as expensive. State highway authorities are mindful of the fact that their limited budgets will buy much smaller amounts of CMA than salt. And consequently fewer miles of road can be cleared with CMA than with salt. Yet studies have shown that salt usage has a very high social cost when all its detrimental effects are considered.

Because of growing concern about the environmental impact of salt usage for highway deicing, in 1976 the Environmental Protection Agency contracted for a research study to identify and economically quantify the social costs of salt usage. The shocking results are summarized in Table V.2. And those are 1976 dollars. The cost in today's dollars would be much higher.

Table V.2

Estimated Annual Cost of Road Salt in the United States

Cost Item	Amount (in millions) $
Water Supplies	150
Vegetation	50
Highway Structures	500
Vehicles	2,000
Utilities	10
Salt Purchase & Application	200
TOTAL COST	2,910

Source: Abt Associates, Inc., An Economic Analysis of the Environmental Impact of Highway Deicing, Environmental Protection Agency, EPA-600/2-76-105, May 1976, p. 1.

The researchers found no way to quantify the greatest cost of all, possible long term health damage due to rising levels of salt in water supplies. In particular cases, they discovered that "the salt levels exceed Public Health Service safety standards set in 1962 and in most cases the levels exceed the standards set by leading researchers, heart specialists and the American Heart Association."[17/] Since that work was completed several states

---

[17/] Abt Associates, Inc., An Economic Analysis of the Environmental Impact of Highway Deicing, Environmental Protection Agency, EPA-600/2-76-105, May 1976, p. 1.

have been faced with law suits over high salt content in water causing health damage.

Research has indicated that CMA is ten times less corrosive than salt.[18] And it has been proven to have virtually no detrimental effect on plants, animals and water supplies. Using the 1976 numbers as a base we can compare the social cost of CMA as a deicer to salt. The results are shown in Table V.3.

Table V.3

Comparison of the Economic Costs of Salt and CMA as a Deicer

Cost Item	Amount (in millions) $	
	Salt	CMA
Water Supplies	150	0
Vegetation	50	0
Highway Structures	500	50
Vehicles	2000	200
Utilities	10	1
Material Purchase & Application	200	2000
TOTAL COST	2910	2251

Even if CMA is 10 times as expensive as salt it has lower social costs. And the long term benefits related to protection of our water supplies could be significantly greater. In most states the additional cost associated with using CMA instead of salt throughout the winter would be equivalent to about $7 per registered vehicle, the cost of two car washes. Surely most taxpayers would be willing to pay that amount in extra auto license fees to reduce the corrosive effects and the resulting depreciation on their auto investments, especially if other benefits to the environment are explained.

---

[18] Carl E. Loche and Kevin J. Kennelley, University of Oklahoma School of Chemical and Materials Science, Corrosion of Bridge Structural Metal by CMA, FHWA/RD-86/064. June 1986.

There can be little doubt that CMA is a more economical product when all costs are considered. That conclusion is what led the Federal Highway Administration to spend several million dollars in research funds to scientifically prove the environmental advantages of CMA and to develop technical production processes.

Recommendations

Corn growers should do everything possible to encourage the use of CMA and to foster the development of commercial production using corn as a feedstock. The minimum target should be a 10 percent share of the deicer market by 1991 which would use 60 million bushels of corn per year. The following specific actions are recommended:

(1) immediately contact the Iowa Department of Transportation to encourage them to make a major test of CMA this coming winter;

(2) all state corn growers associations should contact their state and local highway maintenance officials to inform them about CMA's advantage and to encourage them to conduct trials as soon as possible;

(3) enter into immediate discussions with NYSERDA, Chevron and others in the consortium to arrange for corn substrates to be included in the CMA production research which is underway, the additional Phase I cost is estimated to be $25,000 and the marginal Phase II cost about $75,000;

(4) actively publicize the CMA profit opportunity in order to get other potential producers to consider producing CMA from corn;

(5) explore the possibility of negotiating some equity participation in companies who choose to produce the product from corn in exchange for long term corn grower promotion of the product.

Coal Desulfurization Using Ethanol

While the United States has huge reserves of coal, the high sulfur content of a significant proportion makes it unusable under current EPA regulations without treatment. Several corn belt states have significant reserves of high sulfur coal yet nearby power plants must bring low sulfur coal from other states with high transport costs. Illinois, for example, has large reserves of coal but most of it contains 3-5 percent sulfur. Consequently, even with its large reserves of coal, the state purchases about 18 million tons of low sulfur coal from other states.

Background of the Process

About 10 years ago researchers at Southern Illinois University and the Illinois State Geological Survey began exploring a process for desulfurizing coal using carbon monoxide and ethanol or methanol. The research, also supported by the Illinois Coal Development Board and the Center for Research on Sulfur in Coal, has successfully developed a laboratory process for extracting both organic and inorganic sulfurs. Preliminary economic analysis has indicated that the process should be feasible at the commercial level.

Recent work has indicated that the most economical process may be with the use of ethanol rather than methanol because of a residue of high value by-products. The by-products from a ton of processed coal include:

(1) one half barrel of good quality crude oil;

(2) 25 pounds of carbonyl sulfide which can be used in manufacture of agri-chemicals and pharmaceuticals;

(3) 35 pounds of hydrogen sulfide which can be used in the manufacture of fine chemicals and pharmaceuticals or elemental sulfur;

(4) 8.3 gallons of acetaldehyde (a volume equal to the amount of ethanol used in the process) which can be used for the production of acetic acid or acetone, two widely used chemicals;

(5) an amount of iron sulfide which can be burned to provide some of the heat needed for the process or to produce elemental sulfur.

Thus, all of the carbon monoxide and ethanol used in the process can be converted to useful and economically valuable products. The clear advantage is improved process economics and the lack of an expensive waste disposal problem. The acetaldehyde from the process might be used to produce acetic acid which could be converted on site to calcium magnesium acetate (CMA) for sale as a highway deicer (see previous section).

Current Applied Research

The Illinois Corn Growers Association has recently made a grant to provide funding for the construction of a laboratory-scale continuous-feed reactor. Research with such a reactor is the first step toward assessing how the process might be run on a commercial scale. The Illinois Coal Development Board will also provide continued funding.

The second step in proving commercial feasibility will be the construction and operation of a bench scale reactor and solution of numerous engineering design problems which inevitably appear. The Illinois Corn Growers Association has been instrumental in obtaining $1 million in funding from the State Department of Energy and Natural Resources using Exxon Oil Overcharge Funds. That funding will make possible the construction of a bench-scale reactor as well as technical and economic evaluation of the process at that level.

It therefore appears that as a result of admirably aggressive action on the part of the Illinois Corn Growers Association, funding to carry this research forward through the bench-scale is already in place The next two research phases will take at least two years. After that, assuming the results continue to indicate economic feasibility, the next step will be to arrange for a commercial scale application of the technology.

Economic Feasibility

In March 1986 an evaluation engineer from the Center for Research on Sulfur in Coal submitted a report to the Illinois Coal Development Board providing a preliminary evaluation of the economics of three coal desulfurization processes, including the one of interest here.[19/] That report was based on process

---

[19/] Daniel D. Banerjee, An Economic Evaluation of the Three Processes: Charring, Supercritical Extraction, and In-Situ Catalysts, Submitted to the Illinois Coal Development Board by the Center for Research on Sulfur in Coal, March 14, 1986, p. 1.

research results submitted in early 1985. The report concluded that the cost per ton of coal using the carbon monoxide-ethanol catalytic method would be $134 or $5.02 per million BTU.

In response to that study researchers Shiley and Webster prepared a memorandum indicating that research results in late 1985 and early 1986 had modified many of the parameters assumed in the economic evaluation study.[20/] The major modifications were improvement in the desulfurization process, improvements in the yield of coal due to improved magnetic extraction processes and further information on the value of by-products. Shiley and Webster conclude that the costs using the updated assumptions would be much lower; i.e. $39.85 per ton of treated coal or $1.48 per million BTU.

The average current price (May 1986) of low sulfur coal delivered to power plants in Illinois is $45.70 per ton. Thus, if subsequent research results corroborate the latest cost estimates, the process would be quite feasible.

Potential Corn Usage

It is difficult to estimate the total potential usage of corn which might result from this process; but it is clear that the volume could be enormous. In testimony on the use of Exxon Oil

---

[20/] Richard H. Shiley and John R. Webster, Memorandum to Morris Leighton, "Re: Modification of An Economic Evaluation of the Three Processes: Charring, Supercritical Extraction, and In-Situ Catalysts submitted to the Illinois Coal Development Board by Daniel D. Banerjee on March 14, 1986", April 18,1986.

Overcharge Funds Larry Chamness of the Illinois Corn Growers Association estimated that treatment of the 18 million tons of coal now brought in from outside the state would use about 690 million gallons of ethanol per year.[21/] Production of that amount of ethanol would require 275 million bushels of corn. Illinois consumes a total of 81 million tons of coal per year and U.S. consumption is about 886 million tons per year (Figure V.1).

If the process proves competitive with low sulfur coal, then Illinois and several other states with large reserves of high sulfur coal might be able to more economically use nearby supplies to produce electric power (See Table V.1). The volume of ethanol consumed

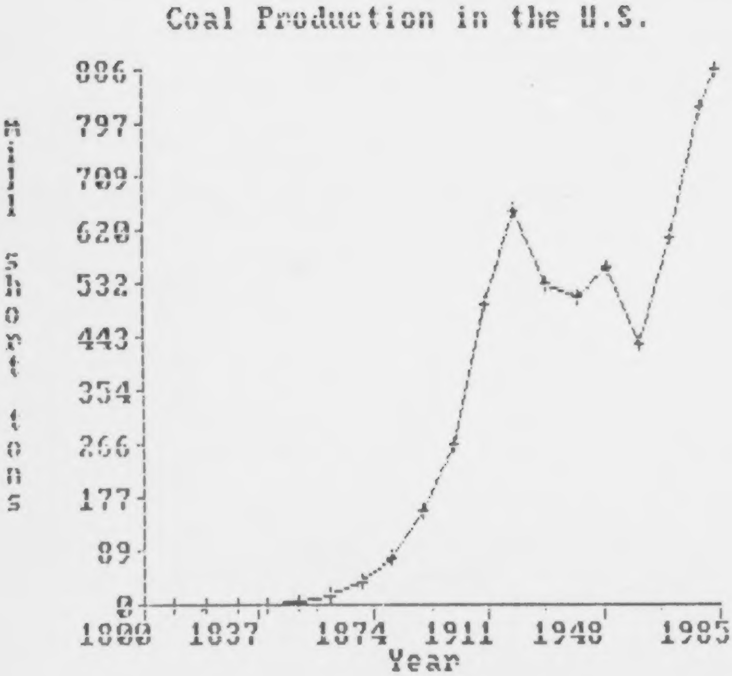
Table V.1
High Sulfur Coal Reserves By State
(1983)

State	Proved Reserves (Percent)
Kentucky	1.2 (east) 3.5 (west)
West Virginia	1.7
Pennsylvania	1.8
Illinois	2.9
Ohio	3.5
Virginia	1.0
Wyoming	.5
Montana	.6
Indiana	2.8
Alabama	1.3
Kansas	4.3
Missouri	5.0

Source: National Coal Association

[21/] Larry Chamness, Chairman, Market Development Committee, Illinois Corn Growers Association," Statement before Public Hearings on Exxon Oil Overcharge Funds," Illinois Department of Energy and Natural Resources, March 26, 1986.

Figure 5.1



Coal Production in the U.S.

could tax the full corn production potential of U.S. corn farmers.

The total capital cost of a 10,000 tons per day facility located near a coal mine or a power plant has been estimated at $875 million.[22/] However, if laboratory and bench scale research continues to indicate that the process can yield a low sulfur coal at prices below alternative energy sources, private energy companies could probably be convinced to provide the funding for the first pilot plant. Some government co-financing might be needed, however, due to the fact that it would be a commercially unproven process and the amount of investment at risk would be extremely high.

Recommendation

Corn growers should do everything possible to see that the research leading to commercialization of this process proceeds as rapidly as possible and to assure widespread visibility for the process. The goal should be to push laboratory and bench-scale tests toward completion within two years with pilot plant construction underway within three years. It appears that funding is already in place for the laboratory and bench-scale analysis. However, the National Corn Growers Association should

---

[22/] Daniel D. Banerjee, An Economic Evaluation of the Three Processes: Charring, Supercritical Extraction, and In-Situ Catalysts, Submitted to the Illinois Coal Development Board by the Center for Research on Sulfur in Coal, March 14, 1986, p. 1.

monitor the process closely and make sure that research funding is not a bottleneck to further development. The NCGA should also make sure that national legislators and potential energy company investors are made aware of the potential environmental (reduction of acid rain problems) and economic benefits. Finally, if the process proves to be economically feasible, the NCGA should use its influence to make sure that investment capital is available from an appropriate combination of private and public sources.

Methanol Cetane Enhancer Using Corn Cobs

It has been widely recognized that methanol produced from coal or natural gas could be an important alternative source of liquid fuel in the United States, especially as oil prices move up and U.S. supplies dwindle. Approximately 1 billion gallons of methanol is currently produced in the United States and is used in a variety of chemical and fuel applications. About 80 percent of that production comes from plants using a natural gas conversion process developed and licensed by Monsanto. The balance is produced from natural gas using other conversion technologies.

Methanol's chemical properties are such as to make it difficult to use in standard gasoline or diesel engines without some ignition enhancing and viscosity improving additive or without costly engine modifications. Neither of those routes has produced a breakthrough which makes methanol competitive as a liquid fuel. But petroleum production and price predictions like those cited earlier in this report continues to spur research on economical ways to convert the huge natural gas and coal reserves of the United States to a more readily usable liquid form.

Background of the Process

For the past several years research, by a Gulf Oil chemist, Dr. J. Gustav Schulz has been aimed at producing a methanol additive from lignite coal. A process was successfully developed. The process uses finely pulverized coal in a slurry of water heated to a temperature of 50 degrees centigrade. Concentrated nitric acid is added and when the reaction is complete the excess acid is removed and recycled. Solubilized lignin is blended with methanol as an additive and the cellulose and ash solids are filtered out.

However, the additive produced from coal had some undesirable physical properties, chiefly high ash content which produced significant engine wear. Dr. Schulz, now with the University of Pittsburgh Applied Research Center, has continued his work with funding from the New York State Energy Research and Development Authority (NYSERDA) and others. The most recent research has focused on using peat and lignin extracted from waste wood products. In the course of that research it was accidentally discovered that corn cob lignin seems to perform extremely well.

Current Applied Research

The laboratory-scale research currently being carried out by Dr. Schulz and funded by NYSERDA and others is focused on experimental production and limited testing of a methanol additive produced from plant lignin employing the process developed by Dr. Schulz. That research phase is likely to be completed in the next few months. The next phase would be to carry out bench-scale production research and to carry out more comprehensive engine tests using sophisticated testing procedures available at one of the diesel engine manufacturer's test facilities. Cummins Engine Company, as a participant in the ongoing research project is a likely candidate. Funding arrangements are not yet complete for the next phase.

After Dr. Schulz found that corn cob lignin seemed to work so well in his process he decided to try producing a methanol fuel enhancer directly from ground corn cobs. The objective would be to save the cost of the lignin extraction process. The process seemed to work beautifully with 65 percent of the cobs being solubilized and the residual being a cellulose material which could have commercial applications. No further research on the use of whole ground corn cobs is currently planned or funded.

Potential Corn Cob Usage

The current annual U.S. consumption of diesel fuel is about 20 billion gallons. Current methanol production is about 1 billion gallons with relatively small quantities being used for fuel.

Assuming the process can produce a cetane enhancer which when blended with methanol produces a fuel which can compete in terms of quality and which is initially priced below (perhaps as much as 20 percent below) diesel, there would be a very large market. If the methanol enhanced fuel were to initially capture a 5 percent market (perhaps in fueling farm trucks and tractors) the total sales would be 1 billion gallons. Assuming the enhancer made up 20 percent of the fuel blend, the quantity of enhancer would be 200 million gallons per year. To produce that quantity of enhancer about 490, 000 tons of corn cobs would be required. A bushel of corn grain production yields 14 pounds of corn cobs. Therefore, the cob production from about 619,000 acres would be required.

If the methanol enhanced blend were to replace all 20 billion gallons of diesel fuel, the corn cob requirement would be about 10 million tons, and the cobs from about 12 million acres would be required.

Recommendation

It is recommended that corn growers accept the invitation of NYSERDA and others in the funding consortium to immediately join the advisory committee. It is also recommended that the NCGA ask Dr. Schulz for submit a proposal to carry out laboratory -scale research on the direct conversion of corn cobs to a methanol fuel cetane enhancer. More detailed economic feasibility analysis should also be a part of that proposal. If the process continues to look technically and economically feasible, the NCGA should provide funding for bench-scale testing, including engine testing at a diesel engine manufacturing company.

Fuel Slurries Using Ethanol and Agricultural Wastes or Lignite

Several upper high plains and western states have substantial reserves of lignite coal, a product which has relatively low heating value but which is nevertheless valuable as a long term source of energy. Research at the University of North Dakota Energy Research Center (UNDERC) has indicated that it may be possible to utilize lignite coal in an aqueous solution with over 5,000 BTU per pound which may then be blended with 10 to 30 percent ethanol to produce an acceptable all-weather fuel for diesel engines.

Background of the Process

Research at UNDERC in the last 3 years has demonstrated that hydrothermally upgraded lignite slurries have equal or better combustion characteristics as bituminous coal slurries. The lignite slurries like bituminous slurries, however, have the disadvantage of high abrasiveness due to the high ash component in the coal. Preliminary tests with peat and sawdust indicate that equally quick burning fuels may be produced by applying this technique to waste biomass, which offers the advantage of very low ash content, making it an attractive engine fuel. Some minor admixture of a liquid or vapor pilot fuel is essential to promote ignition in an engine.[23/] The use of ethanol for this purpose

---

[23/] W.B. Hauserman and G.G. Baker, "The Use of Wood-Derived Slurry Fuels in Diesel Engines", University of North Dakota Energy Research Center, February, 1986.

offers the advantage that it is completely miscible in the slurry, keeping it from freezing.

Current Applied Research

UNDERC is beginning a program of developing coal-water slurries for testing in diesel fuels. The same technology and facilities can produce biomass-water-ethanol slurries that can be tested on the premises. A proposal for funding of the latter has been presented to the North Dakota Agricultural Products Utilization Commission. The Commission has indicated an interest in co-funding by the NCGA and has indicated a willingness to include corn waste products in the raw materials to be tested.

Potential Corn Usage

At this point sufficient research is not available to provide even a rough estimate of the potential corn usage. There could, however, be a doubly beneficial effect for the corn industry since corn waste biomass might be used as a feedstock and since ethanol made from corn grain would be blended as an ignition enhancer.

Economic Feasibility

A recent ecomomic study of the UNDERC hot-water -drying process, by Bechtel Corporation, indicates that a lignite slurry fuel could be produced for $1.40 per million BTU. This assumed lignite available at $11.00 per ton to a plant sized to produce 7.5 million tons per year. Based on a more general study by

Davy-McKee, economic scale factors indicate that a plant scale of about 1 million tons per would increase production costs only slightly. And the smaller scale plant would be much more realistic if corn stover were to be the major feedstock. The UNDERC research proposal estimates that a slurry mixture of 3.9 gallons would be required to replace each gallon of diesel and the cost would be about $.23 per gallon. The final price of a diesel fuel substitute would depend on the amount of ethanol blended and the price of ethanol. But even at 30 percent ethanol and an ethanol price of $1.25 per gallon the price of the fuel would be only $.64. The current depressed price of diesel is in that range.

Recommendation

It is recommended that the NCGA explore the possibility of providing joint funding for the research proposed by UNDERC. If the results are promising additional research will be needed. The NCGA should explore the possibility of arranging for others to assist in funding later research and development. It may be appropriate to explore the possibility of using Oil Price Overcharge funds in North Dakota or some other state for some of that development work.

Other Alternative Uses of Interest

Several other alternatives should be given further consideration. Two others which appear to warrant further consideration in the near term are (1) the use of corn stillage as an adhesive/binder in the production of a solid fuel from municipal solid waste materials and (2) the use of modified corn starch for treatment of wounds (see Chapter IV for a description of each). Sufficient data could not be obtained to provide the kind of detailed analysis given above, but the evidence indicates that further consideration is warranted.

It is recommended that the NCGA explore the possibility of providing a small amount of research funding to further determine the technical and economic feasibility in each of the two uses and to provide an estimate of potential long term effect on corn and corn product demand.

Elevate the Status of Carbohydrate Chemistry

The technical foundation for new uses for corn has been established for a number of decades. As a result of the availability of inexpensive petrochemical feedstocks, renewable resources have been relegated to a distant secondary position. This fact has had a negative impact on research and development of products and processes utilizing corn and other renewable resources.

There is a need for a basic research component to drive the development of new uses of corn. Increased knowledge of the biological and chemical processes for modification of starch and of the molecular structure as it relates to physical and chemical properties are required. New technologies, such as immobilized biocatalysts to modify starch, or new micro-organisms/enzyme systems are needed for developing cheaper or better industrial products. Addition of water soluble ionic esters, glycosylates, etc., will give starch unique characteristics; however, the properties cannot always be predicted. We need to determine these properties experimentally and develop economical methods of introduction of important functional groups, reduce the technical constraints and define reaction kinetics and engineering parameters for industrial scale processes.

ANNEX I

U.S. Department of Transportation, Federal Highway Administration, Offices of Research and Development, Process Development for Production of Calcium Magnesium Acetate (CMA), Report No. FHWA/RD-82/145, Phase I, March 1983, Washington, D.C.

L.G. Ljungdahl, L.H. Carreira, R.J. Garrison, N.E. Rabek, L.F. Gunter and J. Wiegel, CMA Manufacture (II): Improved Bacterial Strain for Acetate Production (draft), University of Georgia Research Foundation, Inc., Center for Biological Resource Recovery and Department of Agricultural Economics, University of Georgia, Athens, GA. June 1986.

Dr. Brian H. Chollar, Calcium Magnesium Acetate (CMA) as an Alternate Deicer, Project No. 3C, FCP Annual Progress Report Year Ending September 30, 1985.

J.C. Wambold, Evaluation of Wet Skid Resistance Using Four Deicing Salts, prepared for the Pennsylvania Department of Transportation Task Order 12, The Pennsylvania Transportation Institute, The Pennsylvania State University, July 1983.

Donald D. Ernst, P.E., Gary Demich, Tom Wieman, CMA Research Project, Washington Department of Transportation.

R. L. Schultz, Report on Evaluation of Wet Skid Resistance Using Various Concentrations of Two Deicing Chemicals, Report No. 188, Washington State Department of Transportation Materials Office, March 1984.

U.S. Department of Transportation, Federal Highway Administration, Research, Development and Technology, Ice-Melting Characteristics of Calcium Magnesium Acetate, Report No. FHWA/RD-86/005, January 1986.

J. H. DeFoe, Evaluation of Calcium Magnesium Acetate As An Ice Control Agent, Research Report No. R-1248, Michigan Department of Transportation, Testing and Research Division, Research Laboratory Section. June 1984.

J. H. DeFoe, Evaluation of Calcium Magnesium Acetate As An Ice Control Agent, Research Report No. R-1248, Michigan Department of Transportation, Testing and Research Division, Research Laboratory Section. June 1984.

U.S. Department of Transportation, Federal Highway Administration, Research, Development and Technology, Preparation of High Quality Calcium Magnesium Acetate Using a Pilot Plant Process, Report No. FHWA/RD-86/006, January 1986.

ANNEX II

ORTHO ICE-B-GON^{TM} DEICER

The Chevron Chemical Company has developed a low corrosion road deicer with significant environmental advantages over conventional road salts using the Federal Highway Administration (FHWA) targeted Calcium-Magnesium Acetate (CMA). The new deicer, Ortho ICE-B-GON^{TM}, uses innovative processing techniques to commercially produce a CMA coated abrasive (sand) as identified by the Iowa Department of Transportation (IDOT).

Many of the advantages of CMA over conventional chloride road deicers (NaCl and $CaCl_2$) have been documented by FHWA FCP Project 3C: Calcium-Magnesium Acetate as an Alternate Deicer, managed by Dr. Brian H. Chollar. The high corrosion, environment and health hazards associated with conventional road deicers are, for practical purposes, eliminated by the use of Ortho ICE-B-GON^{TM}. Some key points about the new deicer are presented here.

1. DEICING POTENTIAL - Laboratory research and field testing in Michigan and Washington (sponsored by the FHWA) show CMA (the active ingredient in ICE-B-GON^{TM}) to be nearly as effective at road deicing as conventional chloride salts. The primary deficiency identified in these field tests was low density of pure CMA, which allowed it to be blown off the road surface before melting the ice and snow. ICE-B-GON^{TM} has a very high density, which will allow even spreading, and then keep it there to do its job.

2. HANDLING EASE - The ICE-B-GON^{TM} production process yields a very uniform product with good flowability and little dust. Extreme dustiness was reported in handling both pure CMA as used in the FHWA tests, and the CMA coated sand material produced and used by the IDOT. ICE-B-GON^{TM} produces very little dust during handling and its uniform size assures even spreading.

3. LOW CORROSION - ICE-B-GON^{TM} is many times less corrosive to bridge steels and automotive parts than are conventional road salts. And, unlike salt, has very little effect on paint or road surfaces. Environmental Protection Agency and Government Accounting Office reports suggest that salt corrosion damage to highways and vehicles costs the American taxpayer several billion dollars annually. The IDOT expects to spend over $6 million in 1986 simply to repair bridge damage done by conventional road deicers.

4. HEALTH - While both ICE-B-GON™ and conventional road salts have relatively low acute human toxicity, ICE-B-GON™ does not contain soluble sodium or chloride which could contaminate the drinking water supply. Numerous water supplies have been contaminated with sodium above the maximum allowed for persons on a low sodium diet (American Heart Association) through the use of conventional road salts.

5. LOW TOXICITY - Environmental studies show that ICE-B-GON™ is significantly less toxic to fish and roadside plants than is conventional road salt.

6. BIODEGRADABLE - Most of the acetate constituent in ICE-B-GON™ will degrade to harmless carbon dioxide and water. The remaining acetate will bind to the soil and be a beneficial organic contribution. The chloride content of conventional road salt, in contrast, will not degrade.

7. SOIL IMPROVEMENT - Ortho ICE-B-GON™ will actually improve roadside soils which have previously been subjected to conventional road salt. This is because the sodium in road salt displaces calcium and magnesium from the soil surface. The use of ICE-B-GON™ will help to replace these essential nutrients.

8. IMPROVED ROADSIDE ENVIRONMENT - The use of ICE-B-GON™ instead of conventional road salts will result in an improved roadside environment. It will also help increase the yield of roadside agricultural crops that have been subjected to salting.

The use of Ortho ICE-B-GON™ Deicer will allow the continued safety of the "bare pavement" policy without today's high cost of highway and vehicle corrosion. It can be used without damaging the roadside environment, and even increase crop yield where conventional road salt use has stripped away essential calcium and magnesium nutrients. While ICE-B-GON™ is more expensive to produce than conventional road salt, it is both many times cheaper, and safer, to use.

DLW

ORTHO ICE-B-GON^{TM} DEICER

(Additional Information)

Use of Ortho ICE-B-GON^{TM} Deicer

Ortho ICE-B-GON^{TM} Deicer uses a new, low corrosion, low environmental impact chemical to effectively melt snow and ice. The alternate deicing chemical, Calcium-Magnesium Acetate (CMA), has been identified by the Federal Highway Administration (FHWA) as the most viable alternative to conventional road salts (sodium chloride and calcium chloride). The Iowa Department of Transportation (IDOT) later recognized that CMA in its pure form is too light for effective field application, and began to pursue the coating of CMA on sand to increase its density. While small field tests showed this to greatly enhance the deicing qualities of CMA, no satisfactory large scale production methods had been developed. Chevron Chemical Company has developed an innovative process for producing CMA coated sand, or, Ortho ICE-B-GON^{TM}.

ICE-B-GON^{TM} can be applied using conventional road deicing equipment, therefore eliminating the expense of retrofitting existing equipment. Its uniform size and density assure that the deicer is evenly spread across the road, eliminating the stripping which can occur with conventional road salts. The high density (75 pounds per cubic foot) keeps the material where it is applied, and helps to pull it through loose snow to the slippery road surface. ICE-B-GON^{TM} wets immediately, without crushing, and the dark sand inside helps to draw heat from the sun, speeding deicing even more. ICE-B-GON^{TM} is effective at temperatures below standard sodium chloride salt and is also better at keeping ice from forming on surfaces such as bridge decks.

The ICE-B-GON^{TM} production process yields a very strong product which will not physically degrade in normal handling. A standard attrition test used in the fertilizer industry shows unmeasurable degradation.

Limited laboratory testing of ICE-B-GON^{TM} by the FHWA shows it to be at least as effective at melting ice as any of the CMA products it has tested. Chevron is now working with the IDOT to complete field testing with five tons of Ortho ICE-B-GON^{TM} this March.

Economic Benefits of Ortho ICE-B-GON^{TM}

The direct cost of using Ortho ICE-B-GON^{TM} is considerably higher than for conventional road deicers, but the benefits far outweigh this. Studies completed by, and for, the Government Accounting Office and the Environmental Protection Agency show that the use of low corrosion deicers could not only improve the environment but save the American taxpayer billions of dollars annually. In 1986 dollars, the cost of deicer damage to bridges and highways totals nearly $1 billion annually. The cost of damage to vehicles is $4 billion annually.

These hidden costs, $5 billion per year, are about 15 times the cost of the salt itself and represent only the corrosion hazards of conventional road deicers. It is impossible to put a monetary value on the environmental and health impact of conventional road salt, but as public awareness is increased more money will need to be spent protecting the nation's water supply and wilderness areas if conventional road salt is used. Many states have been faced with replacing contaminated drinking water sources and modifying highway drainage systems to minimize and control runoff.

Environmental Fate of Ortho ICE-B-GON™

Ortho ICE-B-GON™ will first degrade in the environment to its composition products of calcium, magnesium, acetate, and sand. The calcium and magnesium (essential soil nutrients) will bond to soil particles through a process known as metal-bridging. This bonding process keeps the nutrients near the surface so they are available for plant uptake. This process also keeps the calcium and magnesium attached to the soil, thus unavailable for transport to groundwater. Although it is unlikely to occur, this bond could be broken, thus allowing the calcium and magnesium to reach groundwater. If this were to occur, these nutrients could be rebonded to soil particles at deeper locations or remain in solution in the groundwater as "hard" water.

Acetate, an organic constituent, will be beneficial as a contribution to the organic content of the soil. Approximately two-thirds of the acetate added to the soil will be degraded from acetic acid (i.e., vinegar) to formic acid and sequentially to carbon dioxide and water. (Acetic and formic acid are the most common types of acids present in nature during decomposition processes.)

The remaining one-third of the acetate will remain in the soil and contribute to the organic content of the soil. This acetate is tightly bound to soil particles, thus an unlikely candidate for transport to groundwater.

The sand in Ortho ICE-B-GON™ is an inorganic inert, and will have little or no impact on the environment.

Beneficial Secondary Environmental Effects of Using Ortho ICE-B-Gon™

Ortho ICE-B-GON™ will restore roadside soils which are calcium and magnesium deficient due to conventional road salt applications. Road salt degrades into sodium and chloride ions. The sodium ions are preferentially absorbed onto soil particles, often replacing calcium and magnesium bonding location sites on soil particles. As a result, the calcium and magnesium are leached away from surface soils by rainfall. Although these nutrients are typically rebonded at deeper soil locations, they are often too deep for plant uptake. Application of Ortho ICE-B-GON™ will improve the nutrient quality of soils.

Chloride and sodium contamination of groundwater are a common problem associated with conventional road salt application. Use of Ortho ICE-B-GON™ would eliminate this problem since it does not contain chloride or soluble sodium. Calcium, magnesium and acetate (unlike chloride) are tightly bound to soil particles and, thus, not available for contaminant transport.

Ortho ICE-B-GON™ Impacts on Plants and Aquatic Life

Ortho ICE-B-GON™ is considerably less toxic to plants than conventional road salt. There are numerous incidents cited in the literature which document sodium chloride toxicity to plant life. Conversely, there are only rare cases when calcium and magnesium have been applied to soils at levels (25% +) which will induce phytotoxicity. Due to the low application rates of Ortho ICE-B-GON™, the chances of phytotoxicity occurring from its application are very low.

Ortho ICE-B-GON™ is also less toxic to freshwater fish than is road salt. Sodium chloride is often toxic to fish at levels near 0.1 - 0.3 percent. On the other hand, the aquatic toxicity of CMA (the active ingredient in ICE-B-GON™) is generally one-half to one-third that of sodium chloride.

Human Health and Safety Considerations

Ortho ICE-B-GON™ and conventional road salt have very similar toxicological data; both can be eye and skin irritants and both have relatively low acute oral toxicities.

As with all products containing sand, there is a slight risk of exposure to airborne concentrations of free crystalline silica when handling either ICE-B-GON™ or road salt. However, the sand used in the manufacture of Ortho ICE-B-GON™ goes through extra screening and washing steps which remove fine dusts and, as an essential part of the process, each sand particle becomes coated with calcium-magnesium acetate, thereby inhibiting silica dust formation. It is, therefore, expected that the risk of airborne silica dust would be less with ICE-B-GON™ than with conventional road salt.

DLW
2/25/86

Statement of Gary D. Jolliff, Professor of Crop Science
Oregon State University, and
Member, New Farm and Forest Products Task Force

on

New Farm and Forest Products: Responses to the Challenges
and Opportunities Facing American Agriculture --
A Report from the New Farm and Forest Products Task Force
to the Secretary, U.S. Department of Agriculture,
Washington, D.C., June 25, 1987

Before the

Subcommittee on Agricultural Research and General Legislation
United States Senate
Washington, D.C.
June 26, 1987

Mr. Chairman and Committee Members, my name is Gary Jolliff. It is my pleasure to appear before you today as an employee of a land grant university. I am the only crop scientist who served on the New Farm and Forest Products Task Force. The Council on Agricultural Science and Technology, known as CAST, asked me to serve also as their representative on the New Farm and Forest Products Task Force. I served on their task force which responded to a request from the Joint Economic Committee of Congress for information on new agricultural crops. The response to Congress was made in CAST Report Number 102 entitled: New Crop Development: Needs, Procedures, Strategies, and Options, which was presented in hearings in October, 1984.

For approximately four years I have been closely involved with the practical, historical, and policy issues related to development of new crops.

My remarks will focus on summarizing the conclusions I have made from this experience and research. It is contained in two draft manuscripts submitted for the record of today's hearings. These manuscripts have had substantial review, but nevertheless are my perspective and do not represent the official view of either Oregon State University or the Council for Agricultural Science and Technology.

The majority of my remarks will now focus on summarizing the written testimony submitted. The first is a prepublication manuscript entitled: New Crops and Products from American Agriculture: Rationale for Institutional Change and Strategic Planning. This paper demonstrates that public funding of research and development of new crops has been inadequate in amount and timing to achieve the needed results. It describes why an institutional change is needed to serve the needs of American agriculture. That institutional change must include the establishment of a forceful, enduring, and accountable voice for new crop development to facilitate necessary long-term high-risk multidisciplinary research, development, and commercialization. Such an effort will require vigorous leadership, innovative policies, and tough management.

The New Farm and Forest Products Task Force Report addresses this most fundamental watershed issue. History proves that entities without political representation typically do not receive attention. New crops, almost by definition, do not have political representation. Perhaps it has been unrealistic to expect the USDA to be a sufficiently firm and persistent voice for new crops when large numbers of special interest groups keep the USDA occupied and accountable for what they consider to be equitable distribution of scarce research funds.

Past development efforts on new crops have been initiated with high expectations, and low support levels and duration. The result has been fairly consistent disappointment and disillusionment. It begs the typical response of "I told you so", from those who were not in favor of such investments at the outset. It is very easy for negative attitudes in new crop development to become self-fulfilling prophesies.

Very few persons have had experience domesticating and commercializing a wild plant. Therefore, it is difficult to gain the political support needed to fund such projects for the long haul. This is also true among crop scientists. Even plant breeders will describe the marvelous improvements which can be made in plants through genetics, breeding, and biotechnology; that is, at least for the familiar plants. Those visions and innovations soon fade when the topic is changed to unfamiliar new crops. Thus there is a need for an extension of the 'can-do' mind-set from the familiar to the unfamiliar crops.

Most of us would like instant solutions. It makes accountability nice and tidy. But crop development does not work that way. It was more than 200 years from the time that soybean was first brought to North America until it became one of our most significant crops. Now we marvel at this prodigious plant. But a short 50 years ago there was a struggle for a political voice for soybean.

A second manuscript has been submitted for the record. It is entitled: New Crop Development: Opportunities and Challenges. Attached to this testimony is a map of the eastern half of the U.S. which illustrates the crop adaptation and distribution pattern for soybean acreage growth in the U.S. from 1920 through 1985. That acreage expansion was based on plant breeding and variety development. The growth radiated from centers having plant breeders with access to useful plant germplasm. Such crop development has been common with most major crops, yet the needs for similar breeding of new crops have had meager attention compared to what we know it takes to get the needed results. The same story can be told for the need to develop plant germplasm for new crops. New crops simply have not been given much chance for development.

Based on comments made yesterday to the New Farm and Forest Products Task Force, by your staff, Mr. Chairman, I have made a brief insert in my prepared remarks. It was emphasized that responses to invitations to participate in consideration of legislative action for the development of new crops and products typically included the request for an example of a new crop or product.

Therefore, at the risk of being perceived as biased, I offer you an illustration of a model situation which fits the spirit of the Senate Bill 970 testimony by Senator Harkin, as recorded in the April 9, 1987 Congressional Record -- Senate pages S 4997-4998.

I beg your indulgence as I use a rather personal illustration of what can be done. In less than twenty years at Oregon State University a wildflower native to the Pacific Coast area has been domesticated and commercialized as a new source of industrial oil.

The short timeframe for this achievement may be a record. Few persons have seen such a development within their lifetime. Therefore, it is not surprising that this type of concept is foreign to even farmers and scientists. The effort has been supported primarily at the state level on a shoestring budget. You will be interested to know that it was accomplished without using the new tools of biotechnology. That is why I believe it is a mistake to dictate in Senate Bill 970 that at least fifty percent of the funds be spent on biotechnology. I would emphasize also that this crop probably can be accelerated in its development by the appropriate use of biotechnology.

It is important to note that the uniqueness of the oil in the nutlet of this plant was discovered by U.S.D.A. scientists nearly thirty years ago. They were searching for alternatives to surplus crops. However, U.S.D.A. organizational structure had no provision for developing the plant into a viable economic crop for farmers. And the budget which had been used to discover and characterize the unique products in the oil soon were redirected away from new crops to fund work on the major commodities. This illustrates the types of gaps which have blocked, and continue to block technology transfer.

This new crop presently needs a Foundation for New Farm and Forest Products to launch it as a vigorous producer of wealth for agriculture and U.S. industry. I have with me a proposal which illustrates that State and private funding in Oregon are in a position to form a federal partnership. This is a current example of a critical need for the kinds of organizational capabilities previously described by Dr. Sampson, and detailed in the New Farm and Forest Products Task Force. Incidentally, the name of the crop is meadowfoam (Limnanthes), and the news media can see it being harvested in Oregon for a few more days this year.

Now I will return to the text as previously prepared.

I will conclude my remarks with a reference to a research investment model included in both of the manuscripts mentioned above, and attached to your copy of this testimony. It represents the resources needed during the course of new crop development. The model is general in that the values are relative in both amount and source. The solid lines represent the proposed funding profile through time. The discovery and domestication of potential crop plants is a highly risky proposition and not attractive to private industry or to very many land grant universities and state agricultural experiment stations. Funding of that segment is clearly a U.S.D.A. responsibility.

When potential agricultural utility is identified in the plant domestication process, state agricultural experiment station (SAES) resources become a significant portion of the partnership with U.S.D.A. to begin improving the plant as a potential new crop. Profit potential remains unclear at this point, and private industry probably is not yet interested. With the identification of profit potential, the commercialization process begins and private industry accepts some research funding burden.

Upon launching full crop production, industry begins to finance an ever increasing portion of the research investment. Funding by the U.S.D.A. and the state agricultural experiment stations is reduced as the resources are redirected to other high-risk new crop development efforts.

Contrast the two lines labeled as U.S.D.A. funding. Note the major difference between the solid line of the proposed model and the broken line which depicts historical trends. There are two major and vital consequences of the historical approach. First, note the serious lack of funds at the stages labeled Improvement/Commercialization and Pre-Commercial Development. This results in a technology transfer gap. We have the technology to improve the profitability of crop plants, but the plant remains too undeveloped to attract the private investors to do the job. Public funds are not adequate because the crop does not yet have sufficient economic clout to be politically influential. Presently the meadowfoam commercialization effort is suffering because it is in this political hinterland. This illustrates why Senate Bill 970 needs language to include funding of the commercialization process.

The second serious consequence is the disparity of the two lines at the right margin. This means that a crop production system which has the technology, acreage, industry, and organization to accept major research funding responsibility is not doing so. Furthermore, in addition to not carrying as much as it could, and probably should, it is consuming scarce research resources that are needed elsewhere. The irony, as has been proven with soybean, is that the new crop probably will help most all producers, even if they were not in favor of funding the research. Recent activities such as the first corn utilization conference sponsored by the National Corn Growers Association is evidence of a recognized responsibility by the commodity organizations for self help.

A very significant barrier to new crop development is the political inflexibility available to the U.S.D.A. to redirect funds from major commodity research areas. We all acknowledge that the federal budget for agricultural research is too small. We also know that the potential for spending money on most topics is virtually endless. Therefore, since Congress must, and will, put a lid on expenditures, it follows that the commodity groups which have some capacity to help themselves should do so.

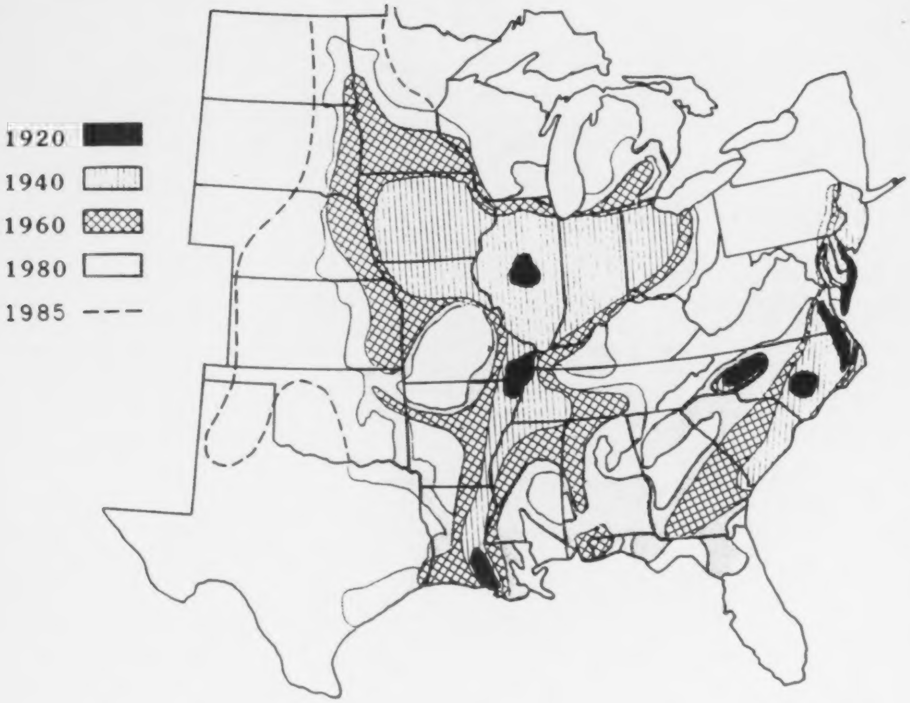
The needed resources for the development of the necessary new crops and products need to be under the control of an entity such as the proposed Foundation for New Farm and Forest Products so as to avoid the continual political dilemma for resource allocation faced by the U.S.D.A. Otherwise it seems that the House and Senate Appropriations Committees would have to do the restructuring of present priorities in agricultural research. I suggest that the Foundation for New Farm and Forest Products, for reason described in Dr. Sampson's testimony, would be the most credible way to prioritize the use of funds for development and commercialization of new farm and forest products.

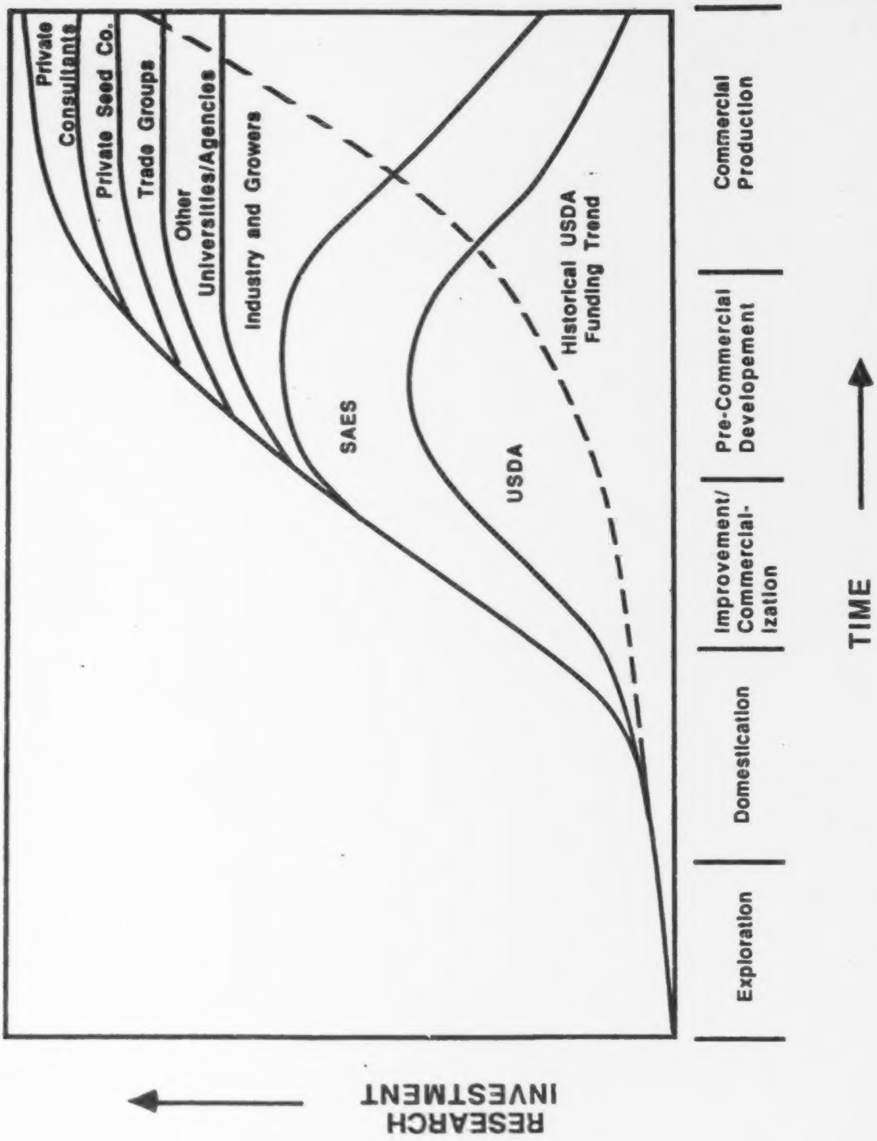
I believe that the U.S.D.A. has had the mandate, the authorization, the talent, and the resources to develop new crops for more than a century. There is a very limited track record for aggressive leadership and serious investment in new crop development. The economic consequences of chronic underfunding of research in new crops have been staggering. I believe that U.S.D.A. has had some serious interest in new crops. But, for the reasons described above, I do not believe that it is politically practical for the U.S.D.A. to achieve, within a reasonable timeframe, what U.S. agriculture needs.

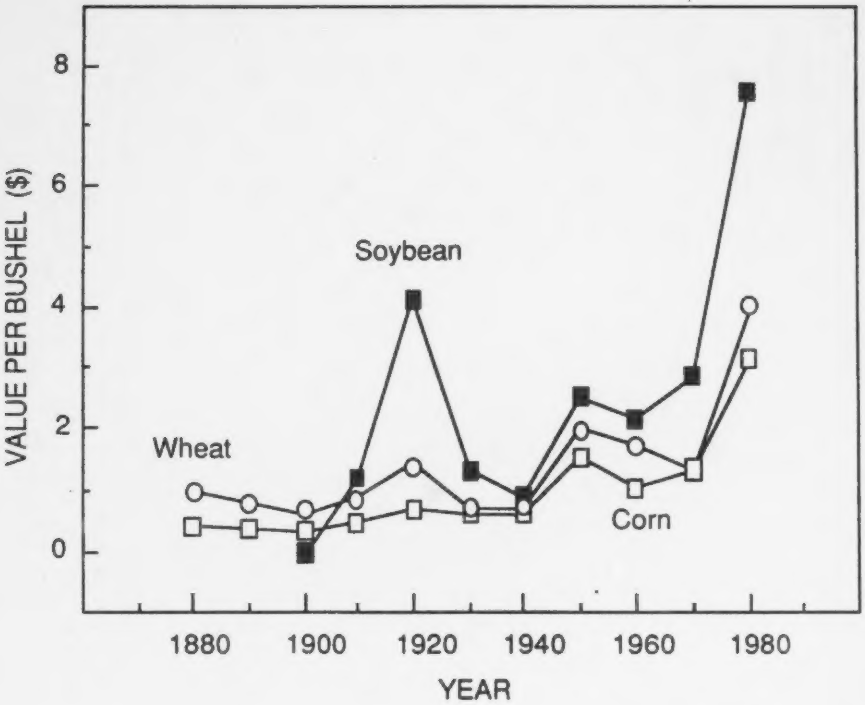
An entity, such as the proposed Foundation for New Farm and Forest Products, is needed. It could alleviate the resource reallocation problem from the outset, and the U.S.D.A. could continue to have the opportunity to invest and cooperate with all the resources it could identify within its many existing programs.

Thank you for your kind attention. I would be pleased to attempt to respond to questions.

26 June 87. GJ


1920
1940
1960
1980
1985


RESEARCH INVESTMENT
TIME
Exploration
Domestication
Improvement/ Commercial-ization
Pre-Commercial Developement
Commercial Production
Private Consultants
Private Seed Co.
Trade Groups
Other Universities/Agencies
Industry and Growers
SAES
USDA
Historical USDA Funding Trend


VALUE PER BUSHEL ($)
8
6
4
2
0
1880
1900
1920
1940
1960
1980
YEAR
Soybean
Wheat
Corn

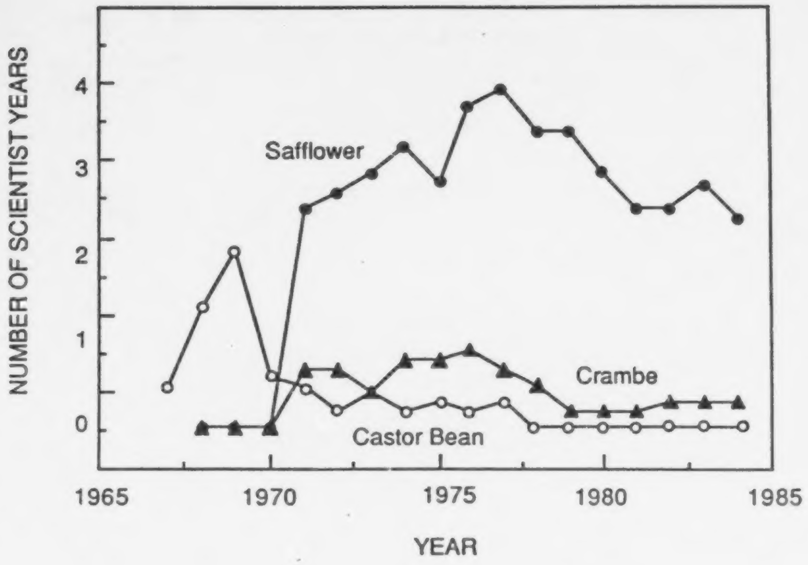


Figure 8. Total Public Sector (USDA and Agricultural Experiment Station) funding invested in safflower, castor bean, and crambe.

Source: United States Department of Agriculture, Cooperative Research Service, Current Research Information System. J.R. Myers, personnal communication, 1985.

Statement by Gary D. Jolliff, Professor of Crop Science
Oregon State University
Member, New Farm and Forest Products Task Force
Before the New Farm and Forest Products Task Force
Washington, D.C.
June 25, 1987

Mr. Chairman, distinguished guests, and colleagues. I summarize the Current Perspectives and Future Needs as follows for crop breeding and genetics:

Current Perspectives

Our nation has done wonders to make existing crop plants so productive that we now have world economic problems. We hear regularly of near boundless new opportunities from plants through use of new tools of biotechnology.

Ironically, in the midst of this success and added potential, there remains a serious need for a voice to apply these existing technologies, both classical plant breeding and otherwise, to new crop development.

While we are flooded with surpluses of major crops it is common for representatives of these commodities to honestly believe that we do not really need to search for new plant materials at this time. This attitude is an ongoing replay of previous eras. I believe such attitudes reflect the desperate feelings of the commodity organizations faced with surpluses, rather than their rejection of new ideas and opportunities.

It appears that, because of these common attitudes within agriculture, USDA has had, and will likely continue to have, political difficulty in garnering and retaining the magnitude of resources needed to develop new farm and forest products at the rate needed by American farmers and foresters.

But, a more serious problem than these attitudes within agriculture, is the lack of an adequate voice to convey information about possible new and alternative crops. Producers of corn, cotton, wheat, alfalfa, oats, and even many dairy farmers were the beneficiaries of soybean as a new crop for the U.S. even though they may have lobbied against soybean research in the late 1800's or early 1900's.

The problem may be getting worse. It appears that farmers, researchers, industrialists, and politicians are becoming more specialized in their acquaintance with agricultural crops. The openness to the prospect, and the process, for new crop development seems foreign to nearly everyone.

This needs to be changed. But the political process in agriculture is *especially* difficult.

I beg your indulgence as I use a rather personal illustration of what can be done. In less than twenty years at Oregon State University a wildflower native to the Pacific Coast has been domesticated and commercialized as a new source of industrial oil. The short timeframe for this achievement may be a record. Few persons have seen such a development within their lifetime. Therefore, it is not surprising that this type of concept is foreign to even farmers and scientists. The effort has been supported primarily at the local level on a shoestring budget. It was accomplished without using the new tools of biotechnology.

It is important to note that the uniqueness of the oil in the nutlet of this plant was discovered by U.S.D.A. scientists nearly 30 years ago. They were searching for alternatives to surplus crops. However, there was no organizational provision for development of the plant as a viable economic crop. And funds which had been used to discover the oil composition soon were redirected away from new crops to fund work on the major commodities. This illustrates the types of gaps which have blocked, and continue to block technology transfer.

The cost of agricultural surpluses in the developed countries of the world in 1986 alone would pay for more than 5000 of the crop domestication/commercialization programs like I just described.

The technology exists to exploit the economic potential of new crops and products as annually renewable alternatives to chronic investment in surpluses.

What are the future needs?

Future Needs

A national voice is needed to coalesce talent, develop our resources, and bring them to commercialization. We cannot afford to wait for existing commodity groups to support, or even entirely condone such efforts. In fact, we can expect resistance to such investments, as happened with soybean. This is one of several important reasons why the organizational entity which handles this task must be appropriately structured.

The national challenge is to focus sufficient public resources on a prudent number of new crops and products to make them profitable, without subsidies, for production on America's farms.

Orderly development of botanical resources is needed to overcome entry barriers and to maximize successes of new farm and forest products. An organized national commitment, with responsible institutional structure, resources, accountability, and continuity over several decades is essential.

Dr. Bloch, Director of the National Science Foundation recently summarized the situation well when he wrote, "New roles for institutions, and more cooperative and innovative relationships among them, will require alteration of some deeply ingrained political attitudes."

Thank you for your kind attention.

DO NOT COPY OR DISTRIBUTE PRIOR TO PUBLICATION

DRAFT SIXTH DRAFT (March 27, 1987) DRAFT

New Crops and Products from American Agriculture: Rationale for Institutional Change and Strategic Planning[1]

Gary D. Jolliff[2]

To be revised for submitting to
Science as a general article.

Contribution from the Dep. of Crop Sci., Oregon State Univ., Corvallis, OR 97331. Oregon Agric. Exp. Stn. Tech. Paper No. _______. Received

---

[1] Prepared as part of the New Farm and Forest Products Task Force Report to the United States Department of Agriculture, Dr. R. L. Sampson, Chairman. The author wishes to acknowledge the assistance of Sieglinde Snapp in the preparation of the manuscript, and the many who contributed through constructive critiques.

---

[2] Professor of Crop Sci., Dep. of Crop Sci., Oregon State Univ., Corvallis, OR 97331.

SUMMARY

Costly chronic agricultural commodity surpluses justify more publicly funded development of new farm and forest product alternatives. Technological tools exist to improve botanical resources for more profitable annually renewable wealth options from the nations 30-70 million acres of excess production capacity. Proposed institutional change and multidisciplinary approaches will require tough management, innovative policies, and vigorous leadership. A forceful, enduring, and accountable voice is needed to facilitate this long-term high-risk research.

INTRODUCTION

Commodity price supports in the tens of billions of dollars (Figure 1) and record farm bankruptcy levels are indicators of what may be viewed as policy-stimulated over-concentration of U.S. agriculture on a few primary crops (35). The result has been economic illegitimate surpluses. The development of wider cropping options is proposed in order to build a newly diversified, competitive base for U.S. agriculture. Justification for new crop development is acute in a world with an enormous, and steadily increasing, capacity for monolithic production. Specific results from new crops and new products cannot be guaranteed nor is it likely that a single new crop soon will be grown on millions of acres. But historical evidence is presented to support the notion that more public funding of such high-risk research is warranted. Over the last 10 years the US government has spent more than $100 billion on domestic surplus agricultural commodity related programs; in 1986 alone an estimated $150 billion was spent on surplus agricultural commodities by approximately 25 affluent countries (D. Avery, personal communication). These data could logically cause urban politicians to question the need for increased agricultural research funding of these commodities in the U.S. Some authors cite the high rate of return on investment as proof that agricultural research is seriously underfunded.

World agricultural production and trade are undergoing dramatic and poorly understood changes that are difficult to project. The Director of the Illinois Agricultural Experiment Station, Dr. Donald Holt, recently stated, "... We may be in danger of underestimating the ability of other nations to develop and apply agricultural technology effectively. For over a hundred years we have had little competition from a largely peasant agriculture of most of the world. That situation is rapidly changing." A ten-fold increase in wheat production in Bangladesh between 1971 and 1981 is illustrative (10). On a larger scale, agricultural exports to China have dropped precipitously since 1981 (46), and China's agricultural output increased by 50% between 1979 and 1985 (4).

Historically, U.S. agricultural research has been focused on increasing yields of established commodities through investment in new technologies. The recently established USDA Office of Agricultural Biotechnology is a case in point. Biotechnology industries promote sales of agricultural inputs for improved production efficiency and competitiveness (1). Enhanced protein synthesis in animals from the use of such new technology will reduce feed demand, adding an estimated 3.4 to 10 million acres of excess crop production capacity to U. S. agriculture (34). This represents a 9 to 25 percent increase above an estimated 40 million acre excess capacity in 1985 (63). It has been suggested that development and marketing of new technologies promoting productivity of existing surplus commodities has taken precedence over long-term national interests (42). The new technologies are valuable tools which could be applied to development of new farm and forest products. Less than one percent of federal sector resources designated for agricultural research in 1984, supported efforts to develop new crops. The proposed 1988 budget for the USDA lacks explicit focus on staffing or strategic plans for development of new farm and forest products. A limited USDA new-crops research infrastructure was developed after the agricultural commodity surplus crisis of the 1950's (33, 35). Through redirection of new-crops funding to other research areas, This program underwent ~~political~~ Severe dismantling during the years when the dominant crops were economically prosperous (I. Wolff, personal communication). New policy directions are needed to insure U.S. agriculture competitiveness in an increasingly self-sufficient and productive world commodity market.

Powerful vested interest coalitions can make political life more divisive, limit the capacity to reallocate scarce resources, and in some cases, initiate a period of economic decline. Lesher (41) places responsibility for ineffective and costly U.S. agricultural policies with well-intentioned, but misguided economists. Iacocca (27) cautions that financial analysts, who often insert themselves in the decision-making process, tend to be defensive, conservative, and pessimistic, while persons in sales and marketing are more aggressive, speculative, and optimistic. New crop development efforts have suffered from all the above types of extremists. Tallent (54) has made the case that top-down management will not improve performance of government-funded research. The best person to decide what research work shall be done is the person who is doing the research. In contrast, Eric Bloch, director of the NSF (6) emphasizes that as expectations of practical results from research increase, scientists will have to be increasingly aware of the public and political environment. Thus it becomes clear that establishing and guiding new crop development efforts is a challenging proposition that warrants special attention, support, and leadership.

U.S. agribusiness is the largest single contributor to the U.S. economy and arguably a very efficient industry (41). Efficient production of major crops may not, however, be enough. Farming constituted only 11.3 percent of the agricultural sector contribution to GNP in 1982 (49). It is suggested that new industrial crops and products might cycle within the domestic economy, generating GNP at rates equal to or greater than GNP generation by commodities currently produced in surplus and exported with little, or no, value added. To compete in today's world market, one of the original Congressional mandates to the USDA, to research "new and valuable plants and seeds", should be heeded (13). Recommendations to this effect have been made for decades (14, 30, 33, 35, 55, 57, 61, 62).

The benefits reaped from recently established new crops (e.g. soybeans, safflower, sunflower, grain sorghum, kiwi) exemplify the need for a sustained strategy of coordinated work to develop new cropping alternatives (32, 35, 45). In countries as diverse as New Zealand, Denmark, and Canada agricultural producers play a significant role promoting development of new plant resources. A case for interdisciplinary approaches to problem solving in the U.S. has been put forth by various authors (5, 23, 44). Institutional models, such as the International Rice Research Institute (IRRI), need to be examined for applicability to the multidisciplinary challenges posed by new crop and new product development. Progress in world rice improvement resulting from 25 years of focused interdisciplinary team efforts compares favorably with advances realized during the previous 5000 years (29). The rate of progress that has been demonstrated for highly domesticated crops, such as illustrated by IRRI rice development work, underscores the potential for developing new plants as crops. Thomas Jefferson has been quoted as saying that "The greatest service which can be rendered any country is to add a useful plant to its culture" (15).

The U.S. has demonstratively lacked an organizational focus in new crop development. Dramatic improvements in crop productivity of established crops over the last half century are indicative of the potential for substantial gains from new crop development efforts. However, increased specialization of agricultural producers and researchers has been necessary for survival. Consequently there are very few experienced leaders to represent the breadth of both present and potential farm and forest products. The challenge is to provide adequate resources to implement multidisciplinary research, to diversify our annually renewable agricultural resources.

NEW FARM PRODUCTS

An overview of present and potential economic benefits from new crops illustrates the critical need for development of new farm products (32, 45). Selected examples of new and alternate crops and new uses for farm products are presented in Table 1. Consumer needs that could be met through utilization of U.S. agricultural resources include: plastics, cosmetics, gasoline and lubricant additives, insecticides, medicines, paper products, super-absorbent polymers, and foods low in fat and cholesterol (35, 50, 53, 57, 61).

New crop development could address a wide variety of environmental concerns. For example: health hazards could be reduced by using vegetable oil to replace petroleum-based plasticizers in industry; plant-derived lubricants that substitute for sperm whale oil could be developed; ethanol from biomass could be used as a fuel to reduce urban lead levels and control atmospheric carbon levels; and perennial crops could replace annual crops on highly erodable land (32, 35, 47, 61).

Many strategic and essential substances, or plant derived substitutes, could be grown in the U.S. (Table 1). Natural rubber, castor oil, and sperm whale oil are examples of strategic materials that by law must be kept stockpiled for defense purposes (61). Domestic production of new crop candidates such as guayule, to supply natural rubber, and jojoba, to supply liquid wax esters would insure protection from source vulnerability for these strategic materials (32, 50). Further, new crops could supply essential U.S. industrial materials such as waxes, resins, gums, newsprint, lubricants, and alternative sources of hydrocarbons used in manufacturing numerous synthetics (57, 61).

The greatest area of opportunity for new agricultural products would be found in applications which do not substitute or compete with current agricultural products but create totally new markets. Meadowfoam, a new source of unique long chain fatty acids, is a case in point (53, 67). Nevertheless, it should be mentioned that increased resource production efficiency, such as use of high fructose sweeteners from corn to replace cane and beet sugar, at a lower cost, benefits society as a whole. Dramatic reductions of sugar crop acreage could spell disaster for cane and beet sugar growers. Potentially, such crop acreage displacement could be eased by the introduction of replacement new crops.

Soybean introduction and commercialization in the U.S. (35) illustrates the magnitude of benefits possible from development of a new crop. Some authorities believe that the appointment in 1907 of a director of soybean research in U.S.D.A., W. J. Morse, was the most important single event in U.S. Soybean history. It established a forceful, enduring, and accountable voice which typically is essential to launch new developments. Investments in soybean research during the early 1900's met stiff resistance (24, 35). Interest in soybean as an oilseed crop in the U.S. was nil until the crisis of domestic vegetable oil shortages during WWI. In 1920 the per bushel value of soybean (>$4.00) was about 4-fold greater than that of corn and wheat (64). This crisis-borne profit potential precipitated the successful transition of soybean from new-crop to major-crop status. Yet soybean research investment levels lagged until after WWII. Over the 60-year period of 1925 to 1985, the total farm-gate cash value (inflation adjusted) of soybean ($188 billion) benefit to the nation's economy (assuming a 2.75-fold multiplier to estimate economic activity) is estimated at 518 billion dollars (2, 12, 59). Unfortunately, soybeans frequently have been a surplus commodity in recent years.

Successful investments in new crop development substantially benefit both producers and consumers (20). A socioeconomic analysis of costs and benefits of a 14-year investment made by Canada in rapeseed (Canola) crop development estimated a 101% annual net return to society (43). The social benefits from improved rapeseed varieties were split approximately equally between consumers and producers.

Development of new farm and forest products should not be viewed as a quick nor complete solution to the problems of most of those who make a living producing the major agricultural commodities. However, soybean filled that role for several decades on many farms. What is the potential for the development of new crops into profitable alternatives? It is impossible to predict the future or to make guarantees, but the historical development of two major U.S. crops, corn and soybeans, provides illustrative models, even though both plants have been domesticated for centuries. During the 20th century, average U.S. yields of corn and soybean increased by 300% (Figures 2 and 3). Agronomic practices and genetic improvements in cultivars are largely responsible for increased production of established crops observed in this century, with an estimated 50% of corn and soybean yield increases being derived from plant breeding efforts alone (8, 11, 21, 48). The labor required to produce a bushel of corn today in the U.S. is approximately one fiftieth of that used in 1910 (59). Similar types of efficiency could be expected as successful alternate crops and products are developed.

An estimated 3000 to 6000 scientist years (SY's*) of publicly funded support have been invested in corn and in soybean over this 300% yield increase period (1920-1985). Currently, corn and soybean receive over 300 SY's of public research, which is similar to publicly funded research investment in wheat and cotton (Figure 4). The total annual cost per scientist year of a well-funded program currently ranges from $150 to 225 thousand (1, 40, 56, 60). If improvement of a new crop follows the development pattern of improvement seen with U.S. corn and soybean, the average total research cost to increase yields by approximately 300% would be an estimated $840 million [based on the average number of SYs invested (4,500) in major crops (over a 300% yield increase period) times an average SY cost of $187,000].

These calculations serve as a first approximate reference from which to evaluate the wisdom of investing in new crop development. It is recognized that investments beyond the public sector have contributed to corn and soybean development, and that significant development of a new crop can occur for less than $840 million. Evenson (18) calculated that private funding of U.S. agricultural research in 1979 was 1.5 times more than public funding. Hundreds of additional SY's per year are invested, in most major surplus crops, by research and development organizations outside the U.S. Therefore, SY investment in the range of 10 to 20 per year focused on a specific new crop appears to be a reasonable minimum for a plant which has not yet attracted private research and development interest. Historically, lower levels of investment in new crop research have been common and have led to long-lasting disappointments (Figures 8, 9, 10). There is a desperate need for the development of realistic expectations from research on new crops, and corresponding support levels. This process would be aided by developing and using accurate historical timetables and investment levels for established crops as a guide.

---

*A scientist year (SY) is the total cost, indirect and direct, of a full-time scientist, support staff, supplies, and equipment for 12 months.

The high risk nature of new crop development is another factor to consider. Not all new crops are appropriate for all agricultural areas and industrial needs. Further, solutions to the seemingly exotic and complex problems in new crop development may appear to be costly compared to well-established commercial crops; however, opportunities for potentially large advances also are present. The yield potential of new crops generally is undeveloped. Dramatic yield increases may be possible within a relatively short time. Recently the oil yield per acre of meadowfoam (Limnanthes spp.) in Oregon was increased 50 percent over an 8-year period at a cost of less than $0.5 million (31); and severe seed shattering in Vernonia was overcome by one germplasm acquisition.

Research to increase the profitability of a new crop, by improving aspects such as yield, quality, utilization options, and marketing, could provide alternate production options for farmers faced with oversupplies of established crops (43). Consider, for example, trading the current $8-14 billion annual value of soybean production for 50-70 million additional surplus acres of corn, wheat, and cotton, which soybean acreage replaced between 1930 and 1980 (2). It would be a significant loss for U.S. agriculture and the U.S. economy. Yet, surprisingly, few persons in the U.S. today consider soybean to be a relatively new crop, and even less emphasis has been placed on the positive role it has had as an alternative crop for surplus acreas of corn, wheat, and cotton. The corn, wheat, and cotton commodity organizations did not provide major political or financial support for the early development of soybean. Federal, state, and university leadership probably will be required also in the future to promote new farm and forest product development. Increased income stability for producers, from increased diversity of crop choices, could provide a basis for prosperity in agriculturally dependent industries and for rural-based communities.

CHALLENGES IN NEW CROP DEVELOPMENT

It appears that the U.S. could benefit from a more aggressive effort to recognize the potential in plants. But new crops face a multifaceted entry barrier. Caution should be exercised to avoid unrealistic expectations from new crops. Abortive efforts to develop crambe production in the 1960's provide a case in point (30). The challenge is in maintaining support during early stages of development before attractive economic returns can be definitely projected.

The low, erratic level of funding for alternative crops such as shown earlier for crambe and castor bean can not provide the critical mass, focus, or intensity needed to overcome the "entry barrier" for a new commodity. The nature of the barrier to new crop development is similar to the resistance-to-takeoff drag experienced by an aircraft (Figure 9). Evenson has described the entry barrier as the minimum critical mass of research effort required to launch an effective program (19). Once over the entry barrier, as when the aircraft wheels leave the ground, or once production of a crop becomes profitable (e.g. soybean), the drag force on crop development (and the political resistance to funding) generally continues to drop as production increases (Figure 10). The development of grain sorghum, hybrid corn, sunflower, and rapeseed all followed a similar pattern. With many candidate new crops, such as crambe and castor bean, support has not been sufficient to produce commercially successful new crops within a time-frame that encourages aggressive sustained private sector investment (Figure 8). The results have been numerous aborted efforts, stalls and crashes (35, 45, 55). You might say that the runway was too short for the combination of drag forces and power of support available.

It took approximately 200 years from the time soybean was introduced in North America (26) until it was established as one of the five major field crops. Approximately 80 years were required to move the concept of hybrid corn from hypothesis to widespread use (38); and much of a century elapsed from the time Daruma type dwarf wheats were first reported in Japan until the dwarf genes were extensively used in high yielding U.S. cultivars (~~17~~ Reitz). These examples of the time requirement for past crop developments serve to emphasize the importance of making long-term commitments to explicit development strategies of the best candidate new and alternate crops. While biotechnology may offer opportunities for new crop development at an accelerated pace, traditional plant breeding and agronomic research will be crucial to improvement efforts (7). Thus, a philosophy and mechanism allowing for a 20-year commitment to improvement of a given new crop appears necessary and minimal.

Before a new crop or product becomes successful, research and development must occur on many different fronts; only an interdisciplinary approach can foster a successful take-off (5, 35). Simultaneous attention to agronomic, plant breeding, processing, utilization, and marketing research are critical to development and commercialization of potential crops (35).

Historically, major crops -- even though domesticated for millenia -- have increased in yield by over 300% with sufficient research investment. Too often new crops are expected to be profitable before appreciable development research has occurred. Estimates of future yield and profit potential and setting of research investment priorities for a given new crop could appropriately be based on yields at least 300% higher than those experienced upon initial domestication or selection. Furthermore, dramatic reduction in costs of producing, harvesting, processing, and marketing can be expected with systems research and engineering developments. But in the U.S., major agricultural research funding has not been forthcoming until a new crop has achieved substantial production, i.e. economic and political clout (e.g., soybean, Figure 5; sunflower, Figure 6). A national shortage of a commodity and the concerted long-term efforts of an individual or an organization to champion a new crop have been necessary to successfully launch a particular new crop, as illustrated by the history of soybean and rapeseed development (22, 35, 68). This crisis-based policy, or non-strategy, has proven to be very expensive.

In 1957 the report of the Task Group on New and Special Crops (55) targeted new crop development in the U.S. to meet industrial needs. Since then the nation has invested only approximately 0.05 to 0.35% of a modest federal agricultural research budget in new crop development (60). Apparently, few, if any, of those efforts were comprehensive and interdisciplinary over a long term. Upon identification of appropriate new or alternative crops by a thorough and objective process, significant long-term public support is needed to overcome the initial, multifaceted barriers to crop development (35). Ironically, research has a history of focusing on increasing yields and efficiencies of commodities produced in oversupply, while no strong voice speaks for the research and development of new or alternative crops.

THE ROLE OF PUBLIC INVESTMENT

Current marijuana production illustrates that a crop plant will be produced by the private sector, even at great risk, without government research and development support if profit potential is high enough. For crops with low short-term profit potential, however, investments during crop domestication and improvement phases (Take-off, Figure 9; and Pre-commercial Development, Figure 10) must be initially supported primarily by the public sector, because private industry is reluctant to invest in most agricultural ventures such as new crop development where fruit from the risk is difficult or impossible to retain beyond a very short time. The private sector will become involved after the potential for profit is demonstrated, i.e., when production, harvesting, and processing technologies are developed and when products and markets are functional. At that time, public resources can be redirected to high-risk research on other new crops and products.

To justify the use of public funds to improve the profit potential of new crops, a comparison can be made between costs of crop development and costs of surplus commodity programs. For illustration purposes, the estimated costs associated with surpluses and research during the decade of the 1980's have been used. Based on precedents, the cost of improving a new crop can be liberally estimated at $840 million (see above). Thus, the costs to the U.S. government of the 1985 wheat diversion program and the 1986 corn-related costs would be equivalent to the estimated cost for improvement of two and ten new crops, respectively (25). If current trends continue, the U.S. will spend enough on farm income stabilization in the decade 1982-1991 ($340 billion) to develop the equivalent of more than 400 new crops. Funding is a necessary condition but not a guarantee of sufficient condition for the successful commercialization of a given new crop or new product. However, based on history, if those crops were carefully chosen, they could be expected to, at least corporately, return wealth to the nation in a manner similar to soybean, $518 billion in 60 years (see above).

Contrasting approaches to public funding of crop improvement are revealed by comparing the relative amount invested in soybean development by the U.S. versus the resources devoted to rapeseed (Canola) improvement in Canada. In 1952, the U.S. had the equivalent of 7.3 public geneticist-breeder scientist years working on soybeans (R. Judd, personal communication, 1986) while the U.S. produced $750 million worth of crop (2, 60), a ratio of 0.0097 geneticist breeders per million dollars of crop value. Over the same time period Canada invested in 1.43 geneticist-breeder scientist years per million dollars worth of rapeseed production (56). The higher the investment per value of crop, the more active and risk-assuming the venture. The Canadian rapeseed development project risked investment at a rate 147 times greater than the U.S. investment in soybean development. The Canadian effort was planned, focused, and coordinated among farmers, industry, government (both federal and provincial), and academia. Today Canada leads the world in edible rapeseed oil exports. The Canadian cooperation is similar to the type of national unity seen in Danish agricultural organization (36). Ruttan and Hayami (52) describe the unity of industry, academia, and government as a prerequisite to progress.

Agricultural research expenditures in Western Europe were similar to North America in 1950, but twice as high as North America by 1980 (58). Worldwide expenditures for public agricultural research increased by 360 percent, after inflation, between 1959 and 1983 (58). During this 20-year period North America's share dropped from 32 percent of world expenditures to 18 percent (58). Several competitors in the world agricultural commodities markets have developed strategies for agricultural technology import and transfer so that the duration of U.S. farmer competitive advantage from early adoption of new technology continues to shrink.

The U.S. reactive approach to crop research support is illustrated by increased investment only after crop production increased (e.g., soybean, Figure 5; sunflower, Figure 6). By contrast, Canadian investment in rapeseed development demonstrates a strategy and a relatively higher research investment before crop production was as large (Figure 7). A relatively high level of initial public investment in research on an appropriate new crop can increase chances for success and profitability. Past experience involving soybean, rapeseed, and sunflower bears this out (21, 35, 43, 56).

WHY A NEW ORGANIZATIONAL ENTITY?

New crop development is needed to expand agricultural options in the face of 30-70 million acres of chronic excess production capacity of the dominant agricultural commodities. This will be even more critical as surplus commodities are produced with greater efficiency (competitiveness) in the U.S. and around the world. What is not clear, however, is how best to implement research and development on new and alternative crops and products. Since the private sector can not be expected to undertake on its own the long-term initial investments needed for new crop development, the importance of a steady source of public support is apparent. The cyclic nature of public investment in identifying and developing new crops and new products has been well documented (33, 35, 55), and it illustrates the need for strategic planning in U.S. agriculture. An ongoing entity, such as an institute or an association focusing on new crops, has been called for by numerous informed writers (33, 35, 45, 55). As we exit the fossil fuel age, it is appropriate to organize and focus national attention on satisfying future consumer and industrial needs from agriculture. It may be timely to modify the agriculture:food stereotype to include more non-food industrial raw materials production.

Bloch describes many of the elements of change needed to foster a national research strategy that would rebuild U.S. economic competitiveness (5). The need for new crops could be a rallying point, but, as Bloch points out, making the proposed institutional change will require "tough management, innovative policies, and vigorous leadership" (6).

The importance of an unbiased institute or organization involved in objectively choosing and promoting the most promising new crops can be seen from the nature of structural bias in the political funding process (23). Public sector agricultural research funding overwhelmingly reflects the interests of established commodities and technological areas of topical interest (e.g. genetic engineering and biotechnology) (19, 39). A need exists for a forceful and enduring voice for new farm and forest commodities research (9, 45, 55). While interest is presently high in new technologies, such as genetic-manipulation tools applied to agricultural research (37, 39), Ruttan has pointed out that "Institutional innovation is both a more powerful and a more reliable instrument of reform than technical change" (51). Likewise, Vietmeyer cautions against too much focus on technology at the expense of promoting the development of renewable sources of wealth such as a new crop (66).

An entity responsible for new crop development would provide the means to develop a strategy and focus new technology to exploit capabilities that give unusual plants value and to solve problems that often prevent their domestication. It could facilitate the development of a collective synergy to allow results surpassing expectations based on past performance. Improved stability of management and research employees could aid in creating and maintaining a stable philosophy and a consistent outlook. The new crop and product development work probably would take place largely within existing agricultural research networks. The University of Minnesota recently established a Center for Alternative Crops and Products ~~Agriculture~~.

The track record of crop improvement research by agencies focusing on specific crops has been highly successful to date. This is illustrated by the remarkable crop improvement progress made at the International Agricultural Research Centers (3, 19, 65). The development of the Canadian rapeseed industry as supported by the Saskatchewan Wheat Pool (68), and improved potato germplasm produced by the International Potato Center and used by over 80 countries (28) are specific examples of the progress possible with long-term support focused on particular crop plants (65).

The multidisciplinary needs in new crop development point to the necessity of a stable, organized effort to foster cooperative efforts. Erich Bloch, director of the National Science Foundation, recently targeted the need for increased emphasis on centers or institutes to foster interdisciplinary research for the purpose of addressing today's complex and challenging problems (5). The establishment of entities to coordinate research efforts and to focus on vital, multidisciplinary areas has been identified as essential to U.S. economic health (5). An institute could nurture user, grower, and processor groups for individual crops or products, greatly decreasing the time required for such necessary groups to organize and operate effectively.

A New Farm and Forest Products Task Force was formed in 1985 to address the potential of diversification in U.S. agriculture and forestry. The task force was an industry-led cooperative effort including government and academia. One of its initiatives was the development of a proposal for the establishment of an organizational entity to promote alternative products from farms and forests. The entity would act as an information and evaluation clearinghouse, and would spearhead cooperative efforts to develop profitable agricultural and forestry options (45). It was proposed to be an independent, nonprofit corporation with a relatively small, entrepreneurial staff. Much care will be needed in the development of the organizational blueprint so as to accomodate the diverse nature of potential projects and participants. Trust funds would be used to foster and sustain collaborative initiatives (joint ventures and matching funds) between the private and public sectors. With total federal and state funding of agricultural research at its current low level (Figure 1), it is difficult to envision an adequate source of funds for such an organizational entity apart from special legislation such as that proposed for trust funds (45) which would be repaid in the future. This entity could provide balance and cooperation with established commodity organizaitons and research technologies to institutionalize a strategic plan for competitiveness and diversivication in U.S. agriculture. Establishing an institute could give needed balance to development and commercialization of new farm and forest products to benefit America. It is conceivable that the U.S. Congress would look with increasing favor on total funding of agricultural research and development which demonstrated strategic plans for commodity production substantially beyond those traditionally in surplus.

CONCLUSION

Technology exists to exploit the economic potential of new crops and products as annually renewable alternatives to chronic investment in agricultural commodity surpluses. The national challenge is to focus sufficient public resources on a prudent number of new crops and products to make them profitable, without subsidies, for production on America's farms.

Orderly development of botanical resources is needed to overcome entry barriers and to maximize successes of new farm and forest product development efforts. An organized national commitment, with responsible institutional structure, resources, accountability, and continuity over several decades is essential.

"New roles for institutions, and more cooperative and innovative relationships among them, will require alteration of some deeply ingrained political attitudes" (6).

REFERENCES

1. Agrichemical Age. 1987. Biotechnology at a crossroads. Agrochem. Age, January 1987, pp. 12I-12L.

2. American Soybean Association. 1985. Soya Bluebook. Am. Soybean Assoc., St. Louis, MO. 270 pp.

3. Avery, D. T. 1984. Food production: The success of the international research centers. Assessments and Research Report 751-AR. Bureau of Intelligence and Research, U.S. Department of State. Washington, D.C.

4. Avery, D. T. 1986. Update on rising world farm output. Speech to Valley National Bank Agricultural Symposium. Phoenix, AZ.

5. Bloch, E. 1986a. Basic research and economic health: The coming challenge. Science 232:595-599.

6. Bloch, E. 1986b. Managing for challenging times: A national research strategy. Issues Sci. Tech. 2(2):20-29.

7. Bonnen, J. T. 1983. Historical sources of U.S. agricultural productivity: Implications for research and development policy and social science research. Am. J. Agric. Econ. 65:958-966.

8. Cardwell, V. B. 1982. 50 years of Minnesota corn production: Sources of yield increase. Agron J. 74:984-990.

9. Carter, C., B. Prentice, and A. Schmitz. 1984. The Economics of Agricultural Research. A discussion paper prepared by the Agricultural Institute of Canada. (Supplement to Agronews, September 1984). Agricultural Institute of Canada, Ottowa, Ontario, Canada. 6 pp.

10. Centro Internacional de Mejoramiento de Maize y Trigo. 1982. Wheat in Bangladesh. CIMMYT Today No. 15. CIMMYT, Mexico City,

Mexico. 15 pp.

11. Chang, T. T. 1985. Germplasm enhancement and utilization. Iowa State J. of Research 59:399-424.

12. Congress of the United States. 1862. An act to establish a Department of Agriculture. In: A. J. Carabelli (ed.) 1972. Abraham Lincoln: His Legacy to American Agriculture. The Associates of the National Agricultural Library, Inc., Beltsville, MD. 20 pp.

13. Congress of the United States. New directions for agriculture: The science and technology of the future. Hearings before the Joint Economic Committee, Ninety-eighth Congress, Second Session, Senate Hearing 98-1129. 2 October, 1984. U. S. Government Printing Office, Washington, D.C. 147 pp.

14. Coppedge, R. D., R. C. Youmans. 1970. Income Multipliers in Economic Impact Analysis. Special Report No. 294. Cooperative Extension Service, Oregon State University, Corvallis, OR. 6 pp.

15. Cunningham, I. S. 1984. Frank N. Meyer: Plant Hunter in Asia. The Iowa State University Press, Ames, IA. 317 pp.

16. Danish Agricultural Council. 1986. Facts on Danish Farming. The Agricultural Council of Denmark, Axelburg, Axeltorv 3, DK-1609. Copenhagen, DK. 4 pp.

17. Evans, L. T. 1980. The natural history of crop yield. Am. Scientist 68:388-397.

18. Evenson, R. E. 1983. Intellectual property rights and agribusiness research and development: Implications for the public agricultural research system. Am. J. Agric. Econ. 35:967-975.

19. Evenson, R. E. 1986. The IARC's: Evidence of impact on national research and extension and on productivity. pp. 1-44. In: Agricultural Research Policy Seminar, 14-24 April, 1986. University of Minnesota, Saint Paul, MN.

20. Evenson, R. E., P. E. Waggoner, and V. W. Ruttan. 1979. Economic benefits from research. Science 205:1101-1107.

21. Fehr, W. F. (ed.) 1984. Genetic Contributions to Yield Gains of Five Major Crops. CSSA Spec. Pub. 7. Crop Science Society of America, American Society of Agronomy, Madison, WI. 101 pp.

22. Forrestal, D. J. 1982. The Kernal and the Bean: The 75-Year Story of the Staley Company. Simon and Schuster, New York, NY. 315 pp.

23. Hadwiger, D. F. 1984. US agricultural research politics: Utopians, utilitarians, copians. Food Policy. August, pp. 193-205.

24. Hartwig, E. E. 1984. Some thoughts after thirty years of soybean research in the South. Soybean News Vol. 35, No. 1. pp. 4-5.

25. Hoppe, R. 1985. The latest scare on farm bills: Politics two, budget-cutting zero. Business Week. 9 December, p. 49.

26. Hynowitz, T., and J. R. Harlan. 1983. Introduction of soybeans to North America by Samuel Bowen in 1765. Econ. Bot. 37:371-379.

27. Iacocca, L. 1984. Iacocca. Bantam, New York, NY. 352 pp.

28. International Potato Center. 1985. Annual Report for 1984. International Potato Center, Lima, Peru. 167 pp.

29. International Rice Research Institute. 1985. International Rice Research: 25 Years of Partnership. The International Rice Research Institute, Los Banos, Laguna, Philippines. 188 pp.

30. Joint Task Force of the Southern Region Agricultural Experiment Stations, USDA, and Industrial Scientists. 1975. New crops and minor oilseed research needs for the Southern Region. Mississippi State University, Mississippi State, MS. 94 pp.

31. Jolliff, G. D., J. M. Crane, R. E. Franz, T. R. Jahns. 1987. Meadowfoam Seed Yield Research. 1986 Report to the Oregon Department of Environmental Quality, Air Quality Division. In press.

32. Jolliff, G. D., and S. S. Snapp. 1987. New crops for profitable agriculture. Prod. Agric. J. 1:In Press.

33. Jones, Q. 1983. Utilization of introduced species as new crops. American Society of Agronomy, Crop Science Society of America, Soil Science of America 1983 Annual Meetings, Washington, D.C. 14 pp.

34. Kalter, R. J. and R. A. Milligan. 1986. Emerging agricultural technologies: Economic and policy implications for animal production. Conference on Technology and Agricultural Policy. National Academy of Science. 11-13 December, 1986. Washington, D.C.

35. Knowles, P. F., K. J. Lessman, W. P. Bemis, M. G. Blase, E. E. Burns, W. C. Burrows, J. H. Copp, R. G. Creech, W. T. Fike, R. E. Garrett, L. D. Hill, S. B. Idso, G. D. Jolliff, Q. Jones, J. F. Miller, J. C. Purcell, R. G. Robinson, R. L. Sampson, D. R. Sumner, A. E. Thompson, R. D. Voss, W. F. Wedin, and I. A. Wolff. 1984. Development of new crops: Needs, procedures, strategies, and options. CAST Report No. 102. Council for Agricultural Science and Technology, Ames, IA. 30 pp.

36. Knudson, P. H. No date. Farmers' organizations. In: Agriculture in Denmark: Farmers' Organizations and the Cooperative Movement.

The Agricultural Council of Denmark, Axelburg, Axeltorv 3, DK-1609. Copenhagen, DK. 32 pp.

37. Kosuge, T., C. P. Meredith, and A. Hollaender (eds.) 1983. Genetic Engineering of Plants: An Agricultural Perspective. Plenum Press, New York, NY. 465 pp.

38. Lee, H. 1984. Roswell Garst: A Biography. Iowa State University Press, Ames, IA. 310 pp.

39. Legates, J. E., R. L. Lower, J. R. Abernathy, D. A. Brown, E. G. Buss, D. R. Campion, G. B. Collins, R. B. Curry, N. S. Fechheimer, R. M. Koch, C. S. Levings, III, O. E. Nelson, Jr., R. L. Philips, T. Richardson, J. G. Scandalios, G. E. Seidel, Jr., G. F. Sprague, A. K. Vidaver, L. D. Van Vleck. 1986. Genetic engineering in food and agriculture. CAST Report No. 110. Council for Agricultural Science and Technology, Ames, IA. 47 pp.

40. LeRoux, E. J. 1983. Canola Council Funding Meeting Address. Agriculture Canada, Research Branch. Winnipeg, Manitoba, Canada. 15 pp.

41. Lesher, W. G. 1984. Assistant Secretary for Economics, USDA. Speech presented at the Conference on Alternative Agricultural and Food Policies and the 1985 Farm Bill. June 11, 1984. Berkeley, CA. 22 pp.

42. Morita, A. 1986. Made in Japan. E.P. Dutton, New York, NY. 309 pp.

43. Nagy, J. G., and W. H. Furtan. 1977. The socio-economic costs and returns from rapeseed breeding in Canada. Department of Agricultural Economics, Technical Bulletin BL:77-1. University of Saskatchewan, Saskatoon, Saskatchewan, Canada. 84 pp.

44. National Academy of Sciences - National Academy of Engineering - Institute of Medicine. 1986. What research strategies best serve the national interest in a period of budgetary stress? Report of a government-university-industry research roundtable conference. 26-27 Feb., 1986. Washington, D.C. 8 pp.

45. New Farm and Forest Products Task Force. 1986. Proposal for establishment of the institute for new farm and forest products (INFAFP). USDA, Washington, D.C. 2 pp.

46. Nohre, C. O. 1986. Agriculture in Asia and the Pacific. pp. 124-127. _In_: L. B. Martin (ed.) 1985 Yearbook of Agriculture. U.S. Government Printing Office, Washington, D.C.

47. Oldfield, J. E., W. F. Wedin, P. K. Fay, B. J. Hankins, R. H. Hart, H. B. Hedrick, W. D. Heffernan, G. H. Heichel, M. K. Johnson, M. B. Jones, G. W. McKee, D. R. Mertens, W. D. Mosher, C. S. Parker, A. W. Pauli, J. G. Purcell. 1986. Forages: Resources for the future. CAST Report No. 108. Council for Agricultural Science and Technology, Ames, IA. 50 pp.

48. Otto, J. O., L. N. Bass, E. Bradford, G. W. Burton, L. J. Butler, G. E. Dickerson, M. E. Dikeman, G. Fassuliotis, F. C. Fliegel, K. E. Gregory, C. Grogan, N. R. Gyles, A. A. Hanson, D. D. King, C. Lewis, C. Long, P. Miller, C. M. Rick, V. W. Ruttan, R. Somes, G. F. Sprague, R. W. Touchberry, D. F. Weber, M. N. Westwood, P. H. Williams, L. L. Wilson, and D. R. Wood. 1985. Plant germplasm preservation and utilization in U.S. agriculture. CAST Report No. 106. Council for Agricultural Science and Technology, Ames, IA. 35 pp.

49. Penn, J. B. 1983. The agricultural and rural economy: Profile,

Reitz, L.P. 1970. New wheats and social progress. Science 169: 952-955 ⊙

30 ~~28~~

current issues, and policy implications. pp. 23-46. In: K. A. Price (ed.) The Dilemmas of Choice. National Center for Food and Agriculture Policy, Resources for the Future, Washington, D.C.

50. Ritchie, G. A. (ed.) 1979. New Agricultural Crops. AAAS Selected Symposium 38. Westview Press, Boulder, CO. 259 pp.

51. Ruttan, V. W. 1982. Agricultural Research Policy. University of Minnesota Press, Minneapolis, MN. 369 pp.

52. Ruttan, V. W., and Y. Hayami. 1984. Toward a theory of induced institutional innovation. J. Develop. Studies 20:203-223.

53. Seigler, D. S. (ed.) 1977. Crop Resources. Academic Press, New York, NY. 233 pp.

54. Tallent, W. H. 1982. Research under pressure. Econ. Bot. 36:4-11.

55. Task Group on New and Special Crops. 1957. Report to President's Bipartisan Commission on Increased Industrial Use of Agricultural Products. Texas Agricultural Experiment Station, College Station, TX. 95 pp.

56. Ulrich, A., H. Furtan, and K. Downey. 1984. Biotechnology and rapeseed breeding: Some economic considerations. A manuscript report prepared for the Science Council of Canada. Ottawa, Ontario. 67 pp.

57. U.S. Congress, Office of Technology Assessment. 1983. Plants: The Potentials for Extracting Protein, Medicines, and Other Useful Chemicals. Workshop Proceedings. OTA-BP-F-23. U.S. Government Printing Office, Washington, D.C. 252 pp.

58. U.S. Congress, Office of Technology Assessment. 1986. A Review of U.S. Competitiveness in Agricultural Trade. A Technical

Memorandum. OTA-TM-TET-29. U.S. Government Printing Office, Washington, D.C.

59. USDA. Agricultural Statistics, 1936 - 1985. U.S. Government Printing Office, Washington, D.C.

60. USDA, Cooperative State Research Service, Current Research Information System. Data files and reports for 1966-1985. Washington, D.C.

61. USDA. 1984. New Uses for Farm Products: Highlights of Secretary's Challenge Forum. Washington, D.C., 11-12 October, 1984. U.S. Government Printing Office, Washington, D.C. 90 pp.

62. USDA. 1985. Industrial agricultural materials development. Departmental regulation No. 1043-26. Washington, D.C. 2 pp.

63. USDA. 1986. Excess capacity and resource allocation in agriculture, 1940-1985. Outlook. October, 1986. pp. 31-33.

64. U.S. Department of Commerce. Statistical Abstracts of the United States. 1930 to 1986. U.S. Government Printing Office, Washington, D.C.

65. U.S. Department of State. Bureau of Intelligence and Research. 1984. Food production: The success of the international agricultural research centers. U.S. Government Printing Office, Washington, D.C.

66. Vietmeyer, N. D. 1986. Lesser-known plants of potential use in agriculture and forestry. Science 232:1379-1384.

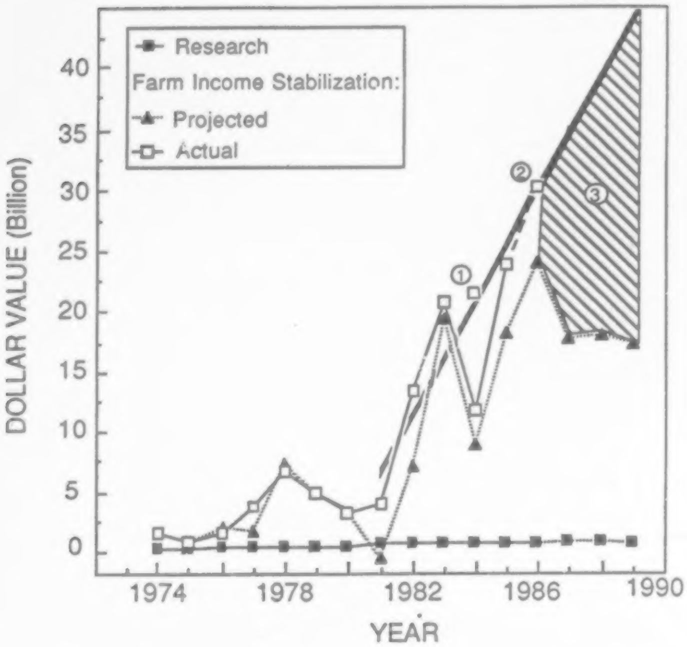
67. West, C. P. 1986. Final Report to the USDA: Technical, Economic and Market Assessment Study of Agricultual Materials as Industrial Feedstocks. USDA-ADODR. U.S. Government Printing Office, Washington, D.C. 66 pp.

68. White, W. J., C. G. Youngs, J. M. Bell, B. R. Stegansson, R. K. Dryden, and B. M. Craig. 1974. The story of rapeseed in Western Canada. Saskatchewan Wheat Pool, Regina, Saskatchewan, Canada. 39 pp.

DO NOT COPY OR DISTRIBUTE

Table 1. Examples of new crop products.

Example products	Crop sources	References
Lubricating Oils Waxes Cosmetics	Jojoba Meadowfoam Crambe	35, 50, 61
Herbicides Insecticides	Sunflower Pyrethrum	35, 53, 61
Rubber Waxes	Guayule	35, 50, 61
Fiber Pulp	Kenaf Poplar	35, 47, 61
Soaps Lubricants	Cuphea Guar	35, 61
Super Slurper	Cereal Starch (Corn, Wheat)	61
Plasticizers	Soybean Crambe Rapeseed	61
Resins Coatings	Soybean Guayule	35, 50, 61



① $21.6 billion = $11.9 buget outlay + $9.7 billion estimated value of Payment-in -Kind (PIK) commodities (W. Bourley, personal communication, 1986).

② Expected (October, 1986)

③ Disparity between current trend and projected outlays.

Figure 1. Federal outlays in agriculture.

Source: Budget of the United States Government, 1974-1986 (Budget function 350).

DO NOT COPY OR DISTRIBUTE

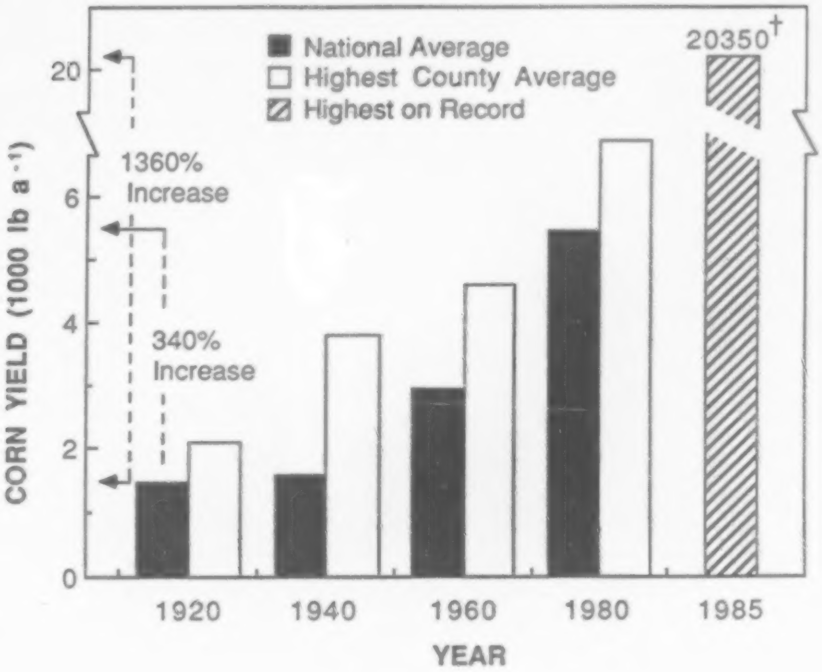


Figure 2. Corn yields in the United States.

Source: National ten year average derived from USDA Agricultural Statistics (1936, 1945, 1965, 1985). Highest county averages from United States Census of Agriculture Summary data, closest available year (1924, 1939, 1959, 1978).

† Highest on record (farmer's field) from Nelson, W.L., and H.F. Reetz, Jr. 1986. Herman Warsaw's high corn yields. Crops Soils 38(8):5-7.

DO NOT COPY OR DISTRIBUTE

34

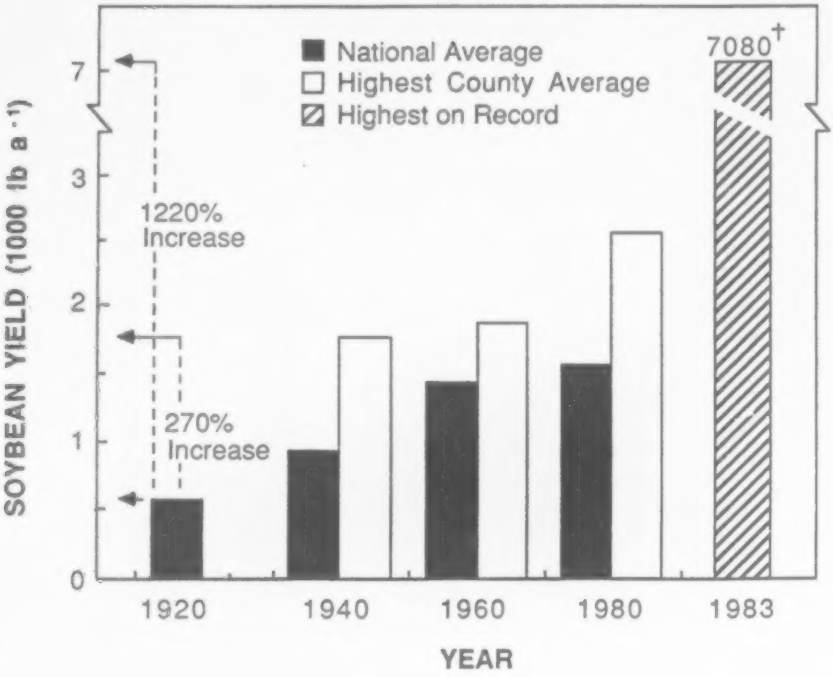


Figure 3. Soybean yields in the United States.

Source: National ten year averages derived from USDA Agricultural Statistics (1936, 1945, 1965, 1985). Highest county averages from United States Census of Agriculture Summary data, closest available year (1924, 1939, 1959, 1978).

† Highest on record from Flannery, R.L. 1983. Soybean research yields top 118 bushels per acre. Better Crops with Plant Food, Winter 1983-84 pp. 6-7.

37
~~25~~

DO NOT COPY OR DISTRIBUTE

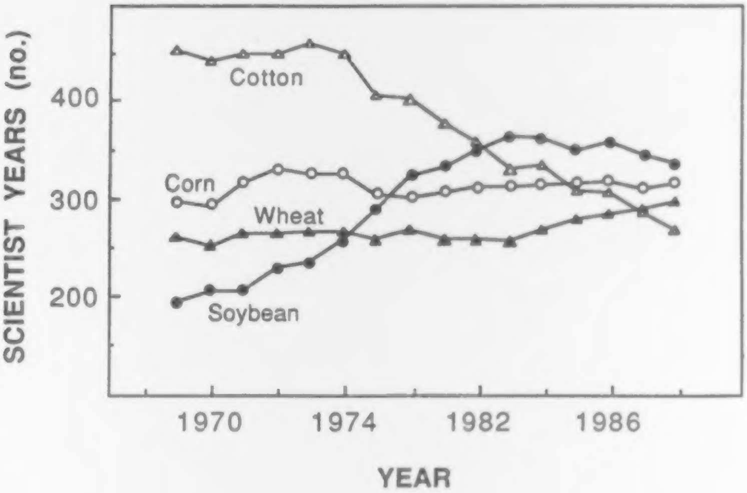


Figure 4. Total public sector (USDA and State Agricultural Experiment Station) funding invested in cotton, corn, wheat, and soybean.

Source: United States Department of Agriculture, Cooperative State Research Service, Current Research Information System, 1986.

DO NOT COPY OR DISTRIBUTE

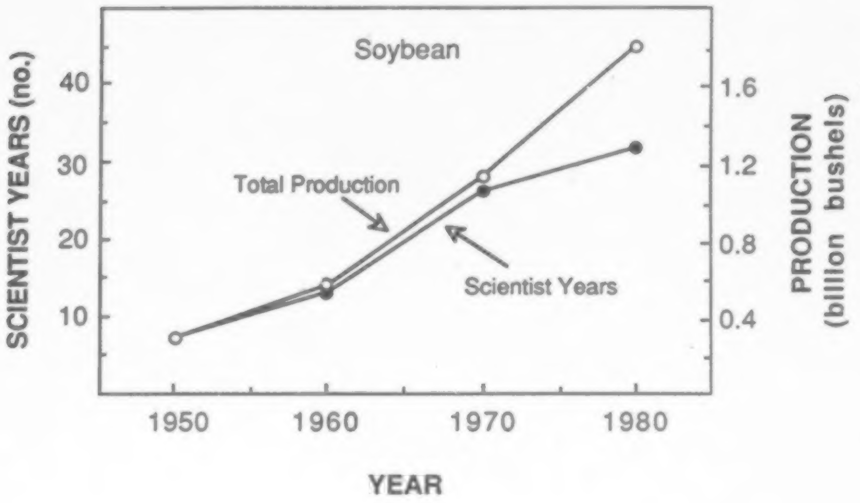


Figure 5. Soybean production and public sector investment in soybean genetics and plant breeding research in the United States.

Source: Scientist Years - R.W. Judd. Past managing director, National Soybean Crop Improvement Council, Urbana, Il. Personal Communication, 1986.
Total Production - United States Census of Agriculture Summary data, 1951 - 1981.

DO NOT COPY OR DISTRIBUTE

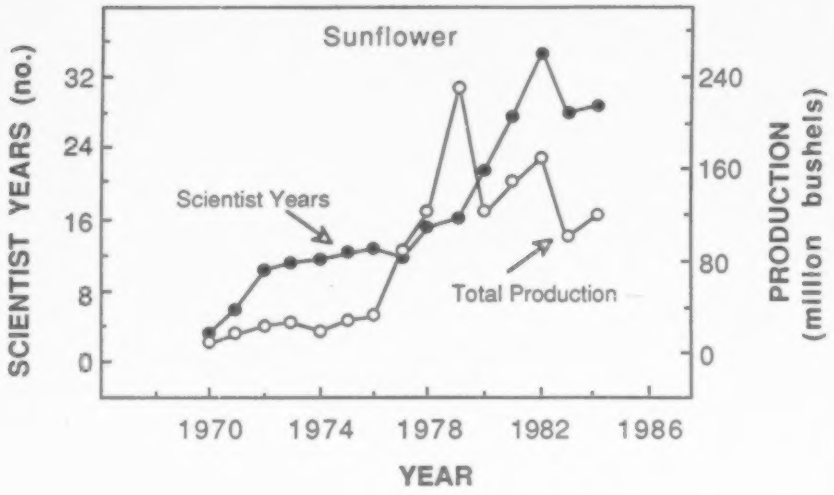


Figure 6. Sunflower production and public sector (USDA and Agricultural Experiment Station) funding invested in sunflower research.

Source: Scientist Years - United States Department of Agriculture, Cooperative State Research Service, Current Research Information System, 1986.
Total Production - United States Department of Agriculture, Agricultural Statistics, 1985. Derived from Tables 177, 178.

DO NOT COPY OR DISTRIBUTE

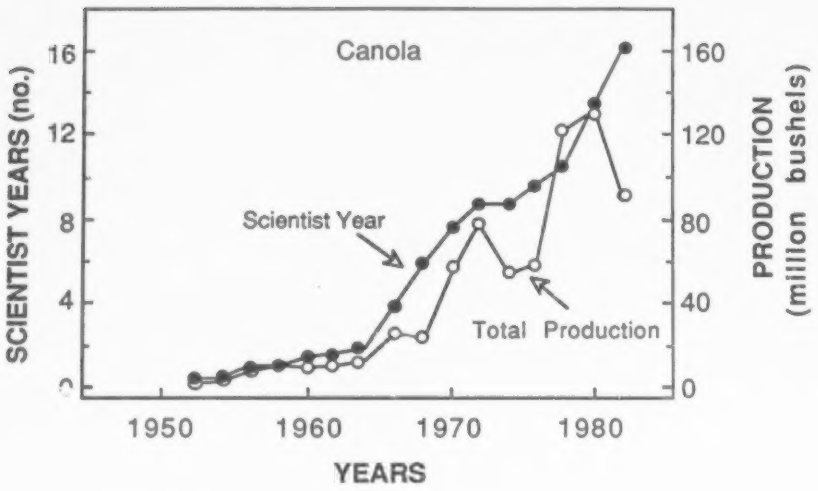


Figure 7. Canola production and public sector investment in canola genetics and plant breeding in Canada.

Source: Scientist Years - Two year average from estimated expenditures on rapeseed breeding work in Canada, 1951 - 1983, Summary of Agriculture, Canada Research Station records (See reference 43).
Total Production - Two year average from Statistics Canada, Field Crop Reporting Series, 1951-1982 (See reference 43).

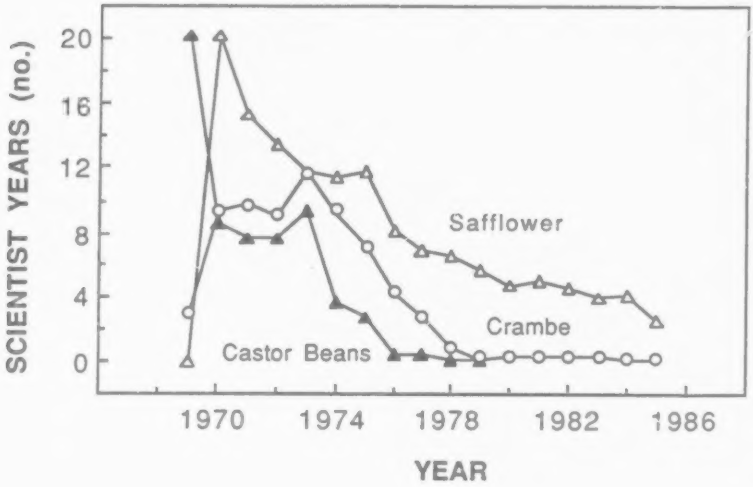


Figure 8. Total public sector (USDA and Agricultural Experiment Station) funding invested in safflower, castor bean, and crambe.

Source: United States Department of Agriculture, Cooperative State Research Service, Current Research Information System, 1986.

DO NOT COPY OR DISTRIBUTE

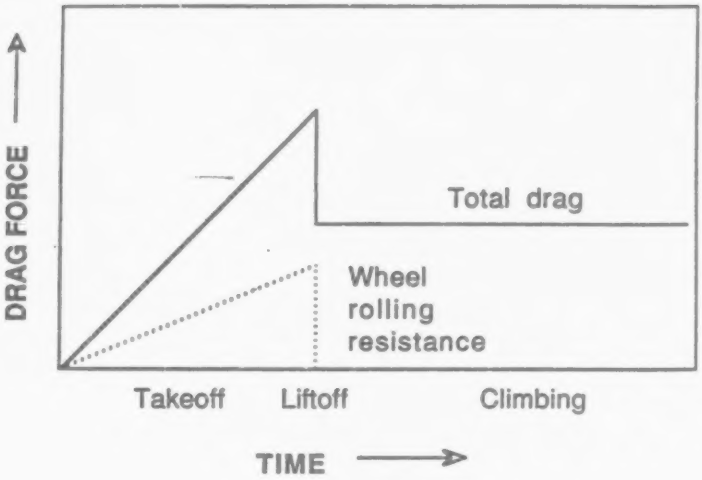


Figure 9. Aircraft takeoff as a model typifying the entry barrier faced in new crop development.

DO NOT COPY OR DISTRIBUTE

4

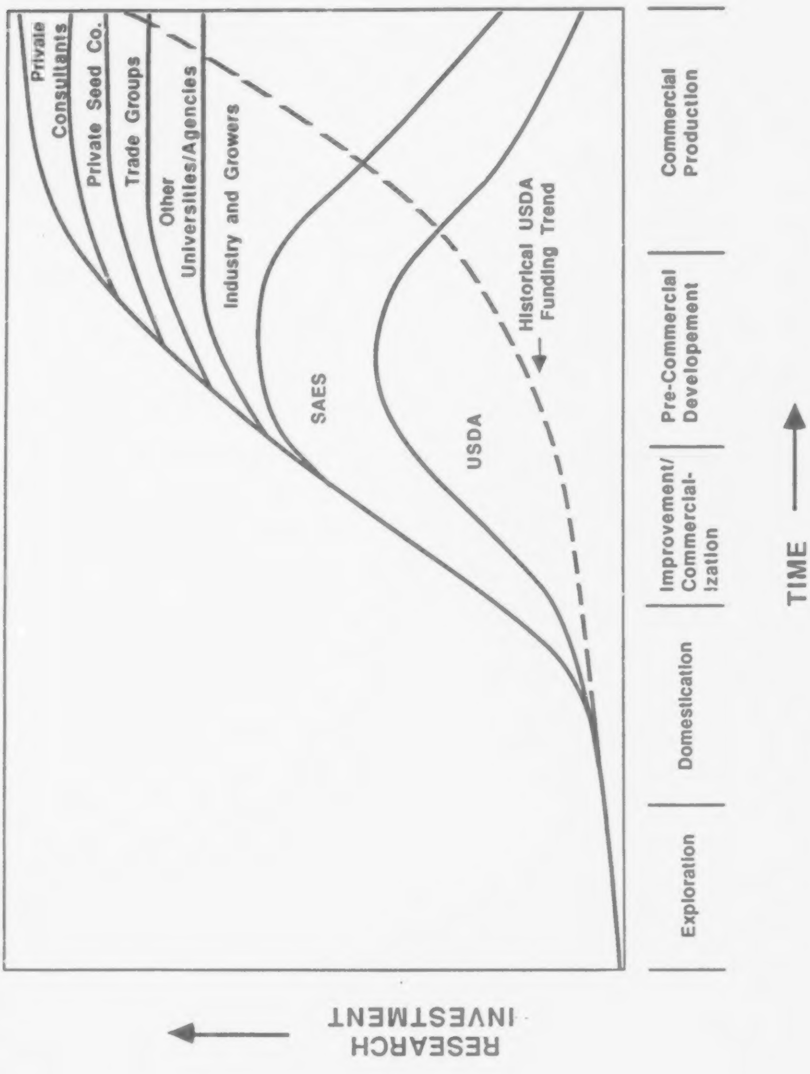


Figure 10. Model of research investment strategies to support commercial development of new crops.

New Crop Development: Opportunity and Challenges

Gary D. Jolliff and Sieglinde S. Snapp[1/]

(Invited review paper for Production Agriculture Journal)

Contribution from the Dep. of Crop Sci., Oregon State Univ., Corvallis, OR 97331. Oregon Agric. Exp. Stn. Tech. Paper No. __________.

Received

[1/] Professor of Crop Sci., and Research Assistant, respectively, Dep. of Crop Sci, Oregon State Univ., Corvallis, OR 97331.

Abstract

The development of new, profitable crops for United States agriculture would address: 1) the challenge to produce more marketable products using lower inputs and under harsh conditions; 2) the on-going crisis of crop surpluses; 3) the unstable economic situation facing growers; and 4) the unfavorable balance of trade. Available new crops that hold promise for United States agriculture include oil-producing wild plant species, ancient food crops of the Inca empire, and high fiber crops for pulp production. In contrast to the promise inherent in potential crop species, new crop development efforts to date have been intermittent. Challenges facing new crop development efforts are explored herein through discussion of a decision matrix approach to problem identification. Our experience with meadowfoam, a plant new to agronomic performance, is used to illustrate critical stages in new crop development. Analysis of Canadian rapeseed and United States soybean development rounds out a discussion of successful approaches to challenges and opportunities in new crop development. The need for cropping alternates to over- produced crops has never been greater. New crops appropriate to diverse agricultural regions have been touched on here, illustrating the potentially profitable alternatives available. A new era in agriculture is possible, based on the comprehensive development of our genetic plant resources; however, it will not arrive without substantial investment in new crop development.

Additional Index Words: Alternate crops, special crops, industrial crops, future crop development, agricultural research policy, agricultural diversification, strategic materials.

Introduction

New crops have been the foundation of United States agriculture. Early colonial farmers were experimenters, evaluating and making selections among crops from the Old World and the New. The development of wheat production in America is illustrative of this process. Wheat was a new crop to North America at the beginning of the colonial period, yet it quickly became the primary commercial crop of the middle colonies (21). Consumers in the United States and around the world are indebted to new crop pioneers, such as the first Midwestern corn growers, and the developers of soybean from insignificance into today's multi-billion dollar agribusiness (11). The resounding success of developing the United States' productive capacity for crops such as corn, wheat, and cotton is underscored by the devastating economic impact of current overproduction. The development of new alternatives to over-produced crops would not provide instant or guaranteed solutions to current economic ills. However, we contend that the future holds opportunity for innovative policy makers, researchers, developers and producers of new crops (11, 27).

Modern agriculture is based on a limited number of crops. Less than 20 crop species provide over 90% of the world's food (27, 30). Dependence on relatively few crop species increases the vulnerability of producers to environmental and economic fluctuations. The expansion of available plant sources for industrial feedstocks and, thus, increased agricultural diversity, has been widely recommended (9, 12, 16, 17, 23, 26, 28). Under-exploitation of our plant resources may have serious economic consequences for American agriculture if the situation is not swiftly remedied.

The potential benefits that can be derived from expanded cropping choices are illustrated by the development of soybean in the United States and rapeseed in Canada (12, 15, 25). Increased stability in grower-income improves the economic picture for the entire rural community. Diversity in crops has also been proposed as a means of attaining improved pest control, increased soil conservation and an improved national balance of trade (12, 26).

New crop development, as discussed here, includes the agronomic development and domestication of wild plant species, as well as the adaptation of established crops to new production areas. Recent reviews by Hinman (5) and by Vietmeyer (27) document that thousands of plant species have been identified as potentially important commercial crops, but await further investigation. Further, tens of thousands of plant species remain unevaluated; the potential for discovering new drug, food, industrial feedstock, fuel, feed and fiber supplies is vast (1, 17, 30).

The conceivable yield potential of new crops is suggested by the greater than 300% improvement in United States corn yields since the beginning of this century (Figure 1). It must be born in mind that development of new crops requires a substantial investment of resources in carefully chosen plants; however, the return from investment in agronomic improvement can be quite high. Evenson et al. (4) estimated the rate of return (over the last hundred years) for public funded agricultural research to be about 85% annually.

This article addresses methods to effectively utilize our renewable agricultural resources. We explore the challenges facing new crop development through historical and current examples. Finally, we discuss possible future directions for new crops in the United States.

New Crops for U.S. Agriculture

New crops could potentially contribute most to United States agriculture through industrial applications, specialty food products and low-input farming (12, 26). A number of potential new crops for American agriculture are presented in Table 1. Industrial feedstocks potentially could rely on a wide variety of annually renewable farm products (1, 8, 18, 28). For example, jojoba oil could substitute for sperm whale oil as an important industrial lubricant (6, 19), crambe oil could serve as a base for new coatings and plastic treatments (26), and meadowfoam oil has unique properties not yet fully exploited (28). Specialty food items such as cashew nuts, tropical fruits, popping beans, and numerous low-fat, low cholesterol plant products could also expand new crop production (12, 26, 27). Plant-derived biodegradable herbicides, new medicines, reduced urban lead levels (from ethanol-enhanced gasoline with reduced lead content), and soil-conserving cover crops are a few of the society-wide benefits that could be derived from the development of alternate crops and new crop products (12, 17, 19, 26).

To be competitive, growers in the United States are increasingly challenged to use farming inputs more efficiently and to make marginal cropping environments productive (19). Producing crops under relatively harsh conditions, such as high salinity, low water availability, and low nitrogen regimes present challenges that might be addressed utilizing new crops (27). A new generation of well adapted crop varieties that are tailored for maximum yields under local conditions can be envisioned.

Specific examples of potential new crops adapted for arid and semiarid regions include: buffalo gourd (5, 6, 19), jojoba (5, 6, 12, 19), and guayule (12, 19). The buffalo gourd is a water-conserving source of starch, biomass, and forage (19). Salinity trials and evaluation of buffalo gourd seeds as a possible source of liquid fuel are in progress (5, 8). Jojoba is a replacement candidate for sperm whale oil to supply liquid wax esters (8). Jojoba meal has also been proposed as a domestic source of tannins (5), an example of a potential new crop substitute to replace imports with domestic production. Guayule, a bushy plant native to the arid southwest, can potentially supply the strategic rubber needs of the United States (19). Arid land in California, Texas and New Mexico could become a center for rubber production. In the 1940's guayule rubber yields were on par with rubber yields from rubber trees (19). Over the last 40 years agronomic research has dramatically increased rubber tree yields, in contrast to guayule yields. A renewed interest in developing guayule as a domestic supplier of natural rubber has been spurred by an increased awareness of the need for domestic control of strategic defense materials (12, 19).

Kenaf is a promising, annually renewable source of fiber (12). The demand for fiber crops to supply pulp for making paper and paper products is steadily increasing (26). Kenaf can be grown in much of the nation south of Iowa. Yields of over 15 tons of stems per acre potentially could allow this crop to compete with pulpwood and to provide a viable cropping alternative to surplus crops such as cotton

(12, 17). Kenaf, as an anually renewable pulp source, provides the advantage of greater flexibility in the use of land, as well allowing forests to be preserved for multiple recreational uses.

Paddy wild rice is a crop still not completely domesticated; nevertheless, it is in commercial production (12). An expanding market provided by rapidly changing diet preferences of U.S. consumers is insuring continued growth in wild rice production (12).

Plants selected for development into commercial crops deserve careful evaluation. Potential new crops typically have traits that can cause immediate developmental difficulties. Cuphea, for example, is a candidate crop for a domestic source of lauric acid for production of soaps and related products (24). Cuphea has a number of undesirable agronomic traits, such as shattering seeds and sticky hairs, that complicate harvest (12). A substantial research investment is required in order to develop an agronomically manageable crop from a wild plant such as cuphea. Crops with seemingly desirable agronomic traits must also be carefully evaluated: they can be the source of unexpected problems upon release. Kudzu is a classic example. Promoted for its soil conservation and forage potential, kudzu has overgrown large areas of the South and become a major weed problem (12). A sustained commitment from the public sector to focused evaluation and development of new crops would minimize risks from premature introduction of new crops.

The depth and variety of untapped potential resources for United States agriculture have been touched on here. However, public sector investment in new crop development has historically been low and has fluctuated drastically, reflecting shifting research priorities and past patterns of research emphasis on the further development of established commodities (11). A strong, sustained voice speaking for new crops has been lacking (16). If benefits from new crop development in the United States are to be realized, changes in national research priorities may be required. With total federal and state funding of agricultural research at its current low level, it is difficult to envision an adequate source of funds for research and development of new crops.

Challenges in New Crop Development

The complex, all-inclusive nature of new crop development has been a major barrier to past development efforts. The failure of just one factor in the equation, such as lack of access to appropriate processing facilities, can spell disaster for the successful growth of a new crop industry (13). It must be borne in mind that the demonstration of profit potential in a new crop may drastically alter its outlook, should entrepreneurial zeal be directed at removing barriers to full production (11). However, to adequately develop a new crop to the point where the potential for profit making is demonstrable, a complex matrix of factors must be characterized and challenges overcome.

The commercial success of a new crop demands an orchestration of development for up to 40 different factors, from availability of high quality seed to maximum market penetration (12). A decision matrix of criteria to consider has been developed to assist in the identification of critical factors effecting the development of a new crop (Table 2). A simultaneous assessment of relevant factors, from production to consumption, is useful in contributing to an understanding of what might be limiting factors (13). Limiting factors need attention before a new crop might be successfully developed. Further, inappropriate new crops for an area can be more easily identified and rejected by use of a decision matrix approach.

A decision matrix can be designed to categorize the resources available in the area under consideration while simultaneously assessing the characteristics of different new crops. As modified from Knox and Theisen, Table 2 presents important steps in production, processing and marketing of a new crop to be considered. Below we discuss some crucial steps in this decision-matrix as illustrated by our experience with meadowfoam in the Pacific Northwest. Meadowfoam is a potential new crop currently undergoing development to produce an agronomically viable crop from a wild plant species (10). Its seeds are a source of long chain fatty acids, a new industrial feedstock for which the market has not been fully defined (18, 28). Meadowfoam serves as an illustration of new crop and new product development in all its ramifications, of which adaption of a crop to a new area (such as the introduction of soybean production to the U.S.) is a more specialized example.

The situation into which a new crop is to be introduced or for which it is to be developed must be considered first. A meticulous cataloging of the land, water and climate resources at hand is useful to clarify potential new cropping alternatives (Table 2). The physical land and climate resources must be further characterized as modified by the economic climate (Table 2). Consider, for example, which land resources are currently underutilized. A new crop with a short growing season requirement could potentially expand land use by facilitating double cropping (5). Introduction and development of a new crop could be considered, to allow more efficient use of land with limited rainfall, or to utilize access to high saline irrigation water (12). If land is currently in high demand for economically viable crops, then development of alternate crops may be less feasible, or necessary, for an area.

Growers in the Oregon Willamette Valley lack cropping options. For example, production on poorly drained soils has been limited to annual ryegrass seed. Alternatives to annual ryegrass are needed to diversify the economic base and to decrease the incidence of field burning, a process integral to grass seed production but the focus of public controversy. Meadowfoam, an herbaceous winter annual native to North America, has potential as an oil seed crop to be grown on the targeted soils (12). Wild meadowfoam species grow in wet habitats and are well adapted to production on poorly drained soils in the Willamette Valley (10).

New crop development is effected by the availability of inputs, such as appropriate herbicides, and factors such as farming equipment currently in use (if a new crop requires a substantial investment in new equipment for production this could be a strong barrier to its development) (13). The financing environment for investment in production of a new crop, and the farming expertise that could apply to it, both have a strong influence on the potential for successful development. A factor contributing to the strong candidacy of meadowfoam as a new crop for the Willamette Valley was the selection of upright plant growth habit with high seed retention ability. This has made possible the use of direct combining in meadowfoam production, using equipment developed for grass seed harvest (10).

Processing facilities, transportation means and marketing have been cited as steps in the new crop development process which can act as bottlenecks to the success of a new crop (12, 13). For example, if a new crop requires specialized processing equipment it must be either transported to where such are available, or facilities must be built nearby the crop production area. Available transportation and processing facilities must be carefully considered in light of the characteristics of the new crops under consideration. Some products are relatively stable, with excellent storage and transportation qualities, which reduces the importance of proximity in processing plants. While extracting and processing techniques have had to be developed to produce high quality oil from meadowfoam seed, few difficulties have been encountered in this area. The oil content and stable qualities of meadowfoam seed have made the location of processing facilities a relatively minor concern in meadowfoam's development. By contrast, this can be a major stumbling block for highly perishable crops such as kenaf, which requires close proximity to pulp processing plants (13).

The market for a new crop product is a crucial ingrediant in successful development efforts (9, 12, 13, 28). An available or readily developed market provides a major incentive for solving problems in production, processing and transport. However, if there is a well-developed market, competition with domestically supplied products already on the market becomes a factor to consider. An ideal new crop would supply either a product currently imported, or a new item for consumption, such as a new food item. In the case of meadowfoam, the the greatest challenge is at this stage: meadowfoam is a source of long chain fatty acids not yet fully exploited as a unique industrial feed stock (10). Potential use, rather than well developed current uses, is a stage that can be difficult to overcome.

Once an adequate market is assured, then questions of sufficient and reliable supply arise. Meadowfoam production in the Willamette Valley is assisted by the presence of the Oregon Meadowfoam Growers Association (OMGA), which could facilitate the smooth scale-up of meadowfoam production should market demand improve (28). An exclusive release by the Oregon Agriculture Experiment Station of 'Mermaid', the first commercial meadowfoam cultivar, to the OMGA provided an incentive for the market and production development work undertaken by the OMGA. Protection of the OMGA proprietary position will likely influence meadowfoam development in the future.

There are many steps in the network that support production, processing and marketing of established crops; establishing simultaneously all of these steps in new crop development is an exercise in coordination. A decision-matrix approach can facilitate the successful pinpointing of factors limiting development at any one point. The challenge then is to identify appropriate new crops for development and to apply a concentrated effort to promote improvement in limiting areas.

Successful New Crops

The development of soybean production in the United States from a minor forage crop to the multi-billion dollar oil crop of today illustrates the challenges and opportunities facing new crop development (Figure 2). How did the dramatic growth in importance of soybean to the United States farmer come about? Acute shortages of vegetable oil during World Wars I and II were accompanied by skyrocketing soybean prices (Figure 3). Soybeans became suddenly profitable, even though the available varieties were low-yielding. This crisis situation was the incentive that pushed soybeans over the "entry barrier" faced by new crops and initiated the commercialization process. A few dedicated advocates also played an important role in promoting soybean to its current prominence (12). Considering that soybeans were introduced in the United States over 200 years ago (7), the development of United States soybean production has not been expeditious. However, the rapid success of the crop once it became a profitable alternative for growers is clear (Figure 2).

Development of the Canadian rapeseed industry bears striking similarities to soybean development in the United States, but also some insightful differences. The Saskatchewan Wheat Board early recognized the need for cropping alternatives for wheat growers (29). The Board committed over 200 Scientist Years (SY, where an average SY is equivalent currently to approximately 200 thousand dollars) over a 30 year period to rapeseed breeding and genetics (3). New varieties were developed for edible oil production. This example demonstrates the potential for a relatively focused investment strategy to overcome the entry barrier to new crop development.

Either a scarcity situation such as described for United States' soybean development, or a planned, sustained research investment approach such as exemplified by Canadian rapeseed development can boost a new crop over the entry barrier. Once a new crop can be grown profitably, challenges such as unique processing requirements or marketing problems will be addressed by both the private and public sectors. By contrast, public support of research is required for initial development of a new crop (11, 12). At the point of development where adequate rates of return on investment can be projected within a short time frame, the development risk becomes quantifiable and the private sector can be expected to address further development needs (Figure 4).

The enormity of the entry barrier facing new crops must be recognized. It is easy to develop unrealisitic expectations of new crops. Development of a crop to the profitable stage requires an intensive, sustained effort (11). The slow commercialization of soybean production in the United States (Figure 2) illustrates the long-term view that is needed in order to set realistic expectations for new crop development. However the potential exists, with available technology, to achieve rapid progress in the development of a new crop. The successful commercialization of rapeseed in Canada demonstrates the effectiveness of a concentrated research effort (15, 25, 28). A relatively modest investment in 1952 of about 1.4 SY (in rapeseed genetics and plant breeding) per million dollar rapeseed value initiated the development of Canadian rapeseed at an unprecedented rate (Table 3). In contrast, compare the .01 SY per million dollar soybean value invested by the U.S. public sector in soybean breeding for the same year (Table 3).

What are the overall societal benefits incurred from a successful new crop development program? The Canadian rapeseed venture is a dynamic example of sustained support by established commodity producers for the development of new cropping options. A recent assessment estimated the internal rate of return on investment in rapeseed at 101% (15). Consumers and society-at-large benefited equally from increased rural prosperity, from a positive balance of trade, and from greater availability of locally-produced edible oil (15). Canadian development of rapeseed as an alternate crop significantly stabilized grower income.

The Future of Agriculture: New Crops' Role

A future United States agricultural scenario, involving full utilization of our nation's capacity to produce an excess of annually renewable farm products, can be envisioned. For example, farmers in the Southwest might grow a variety of water-conserving, low input plants such as buffalo gourd for starch and jojoba for industrial oils (5, 19). Wetter areas in the South might produce tallow from the Chinese tallow tree and pulp from fiber crops such as kenaf (12, 13, 28). Fields of cuphea for soap manufacture, and super-sorghum as a feed-base for industry and fuel, can be envisioned in the Southeast (2, 24). Midwestern fields of corn might be intercropped with a nitrogen-fixing, weed-suppressing and soil-conserving legume. A short season crop such as crambe might be doubled cropped with wheat in the North Central states (28). On the West Coast, locally adapted cultivars of small grains and turf grasses (for seed) might be grown in rotation with industrial feedstock crops such as meadowfoam and pyrethrum (18, 22).

American agriculture, safeguarded by the expansion of cropping options, would utilize soil and water resources more efficiently. Further, strategic industrial feed-stocks would be produced under the control of the United States, contributing positively to the balance of trade. Improved productivity and increased stabilization of farm income and farm soil might be expected from the widespread availability of profitable, locally adapted cultivars. Currently underutilized harsh environments could be made competitively productive.

Methods of accelerating development of profitable new crops for United States agriculture need to be explored. Biotechnology could play an important role in developing cropping alternatives (14). Documenting existing genetic variation would also expand the range of new farm and forest products (27, 30). However, tools such as biotechnology and evaluation of existing genetic diversity may not necessarily be used effectively. It has been argued that institutional reform can be a reliable means of bringing about needed change (20). The establishment of a dynamic, multidisciplinary entrepreneurial institute focused on new farm and forest products has been proposed recently by a national task force (16). Members of industry, government, academia, and production agriculture, working together in a collaborative, multidisciplinary approach have an opportunity to foster accelerated new crop development (12, 16).

The benefits for consumers and producers alike from the improvement of cropping alternatives cannot be ignored. Our renewable agricultural resources are only beginning to be tapped. Useful first steps would include a realization of the complexity involved in new crop development, such as identified in the decision-matrix approach, and implementation of a unified, "can-do" attitude throughout agriculture. Hopefully, substantial and responsible research in new crop development is forthcoming.

References

1. Adams, R.P., and McChesney, J.D. 1983. Phytochemicals for liquid fuels and petrochemical substitutions: Extraction procedures and screening results. Econ. Bot. 37:207-215.
2. Busche, R.M. 1985. The business of biomass. Biotech. Progress 1(3):165-180.
3. Downey, K. 1983. Estimated expenditures on rapeseed breeding work in Canada, 1951-1983. Agriculture Canada Research Station Records. Saskatoon, Saskatchewa, Canada.
4. Evenson, R.E., P.E. Waggoner, and Y.W. Ruttan. 1979. Economic benefits from research: An example from agriculture. Science 205:1101-1107.
5. Hinman, C.M. 1986. Potential new crops. Sci. Am. 255:33-37.
6. Hogan, L., and W.P. Bemis. 1983. Buffalo gourd and jojoba: Potential new crops for arid lands. Adv. in Agron. 36:317-349.
7. Hymowitz, T., and J.R. Harlan. 1983. Introduction of soybean to North America by Samuel Bowen in 1765. Econ. Bot. 37:371-379.
8. Johnson, J.D., and C.W. Hinman. 1980. Oils and rubber from arid land plants. Science 208:460-464.
9. Joint Task Force of the Southern Region Agricultural Experiment Stations, USDA, and Industrial Scientists. 1975. New crops and minor oilseed research needs for the Southern Region. Mississippi State University, Mississippi, MS. 94 pp.
10. Jolliff, G.D. 1981. Development and production of meadowfoam (Limnanthes alba). E.H. Pryde (ed). New Sources of Fats and Oils, American Oil Chemists' Society Monograph No. 9. AOCS, Champaign, Il. pp. 269-285.

11. Jolliff, G.D. 1986. Report to the New Farm and Forest Products Task Force. Washington, DC. 18 pp.

12. Knowles, P.F., K.J. Lessman, W.P. Bemis, M.G. Blase, E.F. Burns, W.C. Burrows, J.H. Copp, R.G. Creech, W.T. Fike, R.E. Garret, L.D. Hill, S.B. Idso, G.D. Jolliff, Q. Jones, J.F. Miller, J.C. Purcell, R.G. Robinson, R.L. Sampson, D.R. Sumner, A.E. Thompson, R.D. Voss, W.F. Wedin, and I.A. Wolff. 1984. Development of new crops: Needs, procedures, strategies, and options. CAST Report No. 102. Council for Agricultural Science and Technology, Ames, IA. 30 pp.

13. Knox, E.G., and A.A. Theisen (eds). 1981. Feasibility of introducing new crops: Production - Marketing - Consumption (PMC) systems. Final report prepared for the National Science Foundation by Soil and Land Use Technology, Inc. of Columbia, MD. Rodale Press, Emmaus, PA. 205 pp.

14. Kosuge, T., C.P. Meredith, and A. Hollaender (eds). 1983. Genetic engineering of plants: An agricultural perspective. Plenum Press, New York, NY. 465 pp.

15. Nagy, J.G., and W.H. Furtan. 1977. The socio-economic costs and returns from rapeseed breeding in Canada. Department of Agricultural Economics, Tech. Bull. BL:77-1. University of Saskatchewan, Saskatoon, Saskatchewan, Canada. 84 pp.

16. New Farm and Forest Products Task Force. 1986. Proposal for establishment of the institute for new farm and forest products (INFAFP). USDA, Washington, DC. 2 pp.

17. Office of Technology Assessment, U.S. Congress. 1983. Plants: The potentials for extracting protein, medicines, and other useful

chemicals--workshop proceedings. OTA-BP-F-23. U.S. Government Printing Office, Washington, DC. 252 pp.

18. Princen, L.H. 1983. New oilseeds on the horizon. Econ. Bot. 37:478-492.

19. Ritchie, G.A. (ed). 1979. New agricultural crops. AAAS Selected Symposium 38. Westview Press, Boulder, CO. 259 pp.

20. Ruttan, V.W. 1982. Agricultural research policy. University of Minnesota Press, Minneapolis, MN. 369 pp.

21. Schlebecker, J.T. 1975. Whereby we thrive: A history of American farming, 1607-1972. The Iowa State University Press, Ames, IA. 342 pp.

22. Siegler, D.S. (ed). 1977. Crop resources. Proceedings of the 17th Annual Meeting of the Society for Economic Botany. Academic Press, New York, NY. 233 pp.

23. Task Group on New and Special Crops. 1957. Report to the President's Bipartisan Commission on Increased Industrial Use of Agricultural Products. Texas Agricultural Experiment Station, College Station, TX. 95 pp.

24. Thompson, A.E. 1984. Cuphea - A potential new crop. Hort. Science 19:352-354.

25. Ulrich, A., H. Furton, and K. Downey. 1984. Biotechnology and rapeseed breeding: Some economic considerations. A manuscript report prepared for the Science Council of Canada. Ottawa, Ontario, Canada. 67 pp.

26. USDA. 1984. New Uses for Farm Products: Highlights of Secretary's Challenge Forum. 11-12 October, 1984. U.S. Government Printing Office, Washington, DC. 90 pp.

27. Vietmeyer, N.D. 1986. Lessor-known plants of potential use in agriculture and forestry. Science 232:1379-1384.

28. West, C.P. 1986. Final Report to the USDA: Technical, economic and market assessment study of agricultural materials as industrial feedstocks. USDA-ADODR. U.S. Government Printing Office, Washington, DC. 66 pp.

29. White, W.J., C.G. Youngs, J.M. Bell, B.R. Stegansson, R.K. Dryden, and B.M. Craig. 1974. The story of rapeseed in Western Canada. Saskatchewan Wheat Pool, Regina, Saskatchewan, Canada. 39 pp.

30. Wilson, E.O. 1985. The biological diversity crisis: A challenge to science. Issues in Sci. and Tech. 2(1): 20-29.

List of Tables

Table 1. Examples of new crop products.

Table 2. Decision matrix for new crop development.

Table 3. Comparison of United States and Canada public sector investment in soybean and rapeseed development, respectively.

Table 1. Examples of new crop products.

Example products	Crop sources
Lubricating Oils Waxes Cosmetics	Jojoba Meadowfoam Crambe
Herbicides Insecticides	Sunflower Pyrethrum
Rubber Waxes	Guayule
Fiber Pulp	Kenaf Poplar
Soaps Lubricants	Cuphea Guar
Plasticizers	Soybean Crambe Rapeseed
Resins Coatings	Soybean Guayule

Table 2. Decision-matrix for new crop development (modified from Knox and Theisen, 1981).

COMPONENT DESCRIPTION	PHYSICAL PRESENCE	ECONOMIC CLIMATE
- PRODUCTION RESOURCES AVAILABLE -		
Land Resources		
Water Availability		
Climate Atributes		
Input Procurement and Availability		
Seed		
Fertilizer		
Farm Labor		
Farm Equipment		
Pest Control		
Production Expertise		
Crop Organizations		
Agricultural Research Programs		
Market Information for Farmers		
- PROCESSING AND MARKETING -		
Potential for Dependable Supply		
Procurement Resources and Financing		
Government Services and Regulations		
Market Intelligence		
Transport and Storage Facilities		
Processing		
Resources		
Equipment		
Research		
Information Programs		
Commodity Institutions		
Market Penetration		
Market Size		
- PLANT CHARACTERISTICS -		
Adaption to Environment		
Production Level		
Expertise Required		
Inputs Required		
Market Development		
Product Versatility		
Competition with Domestic Supply		

Table 3. Comparison of United States and Canada public sector investment in soybean and rapeseed development, respectively.

			Public geneticist/breeders			
	Crop value (million $)		Scientist Years (SY) (No.)		Ratio (SY/million $)	
Year	U.S. soybean	Canada rapeseed	U.S. soybean	Canada rapeseed	U.S. soybean	Canada rapeseed
1952	750	.21	7.3	0.3	.010	1.428
1962	1,544	20	13.0	1.5	.008	.075
1972	3,560	168	26.0	8.5	.007	.051
1982	12,000	514	32.0	15.8	.003	.031

Source:
Ulrich, A., H. Furtan, and K. Downey. 1984. Biotechnology and rapeseed breeding: Some economic considerations. A manuscript report prepared for the Science Council of Canada. Ottawa, Ontario. 67 pp.
Judd, R. W. Past managing director, National Soybean Crop Improvement Council, Urbana, IL. Personal communication, 1986.

List of Figures

Fig. 1. Corn yields in the United States. 1920-1980.

Source: National and highest county averages from United States Census of Agriculture Summary data. 1921-1981.

Highest on record (farmer's field) from Nelson, W.L., and H.F. Reetz, Jr. 1986. Herman Warsaw's high corn yields. Crops Soils 38(8):5-7.

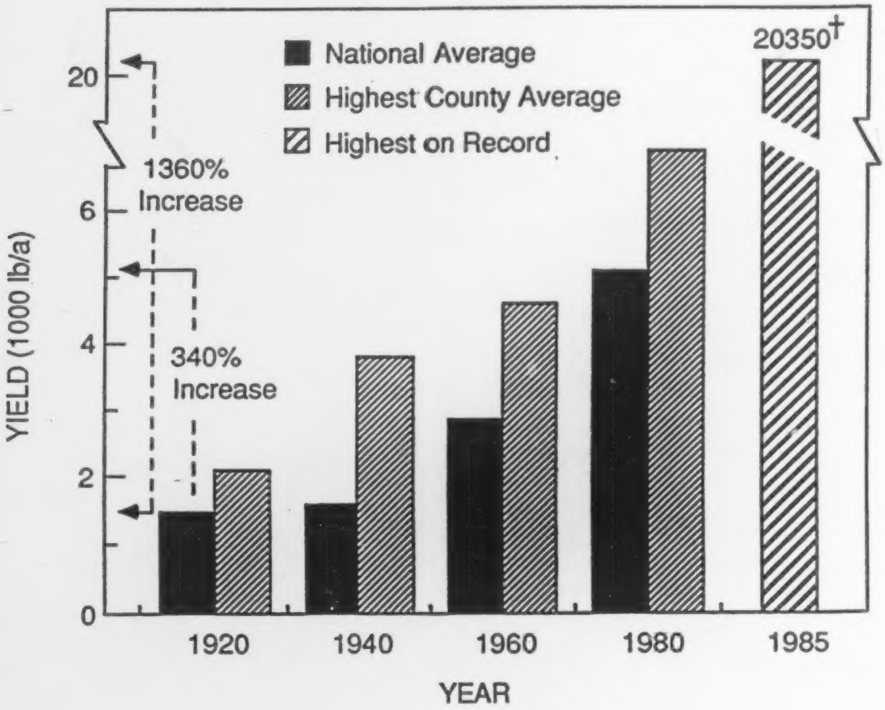
Fig. 2. The expansion of soybean production in the United States during the present century. The acreage for the reported 1985 expansion might be limited in some areas.

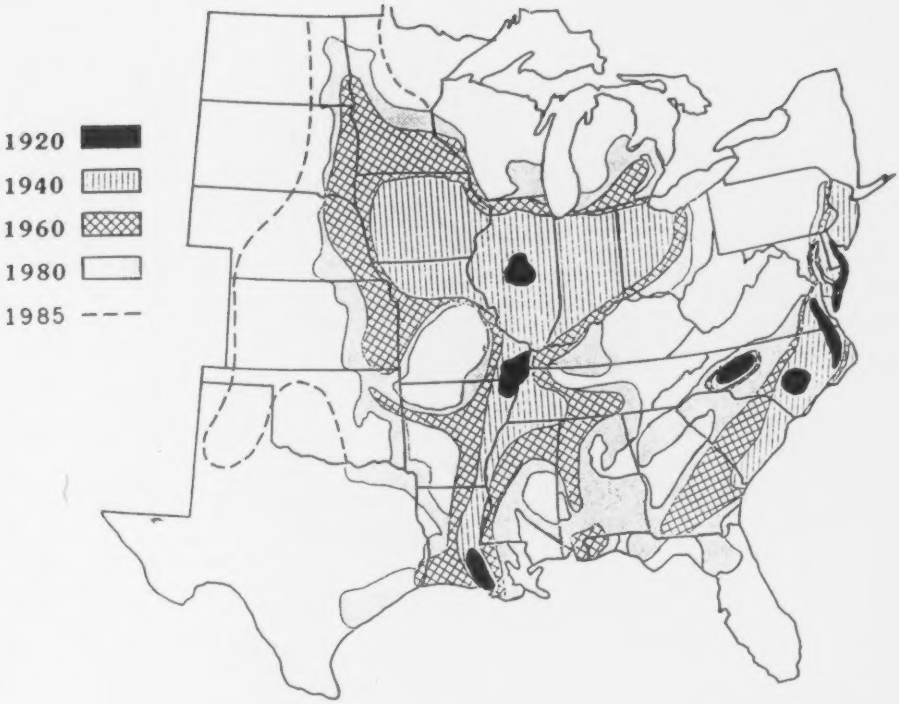
Source: The map was drawn on the basis of information compiled from the United States Bureau of Census and the USDA Statistical Reporting Service.

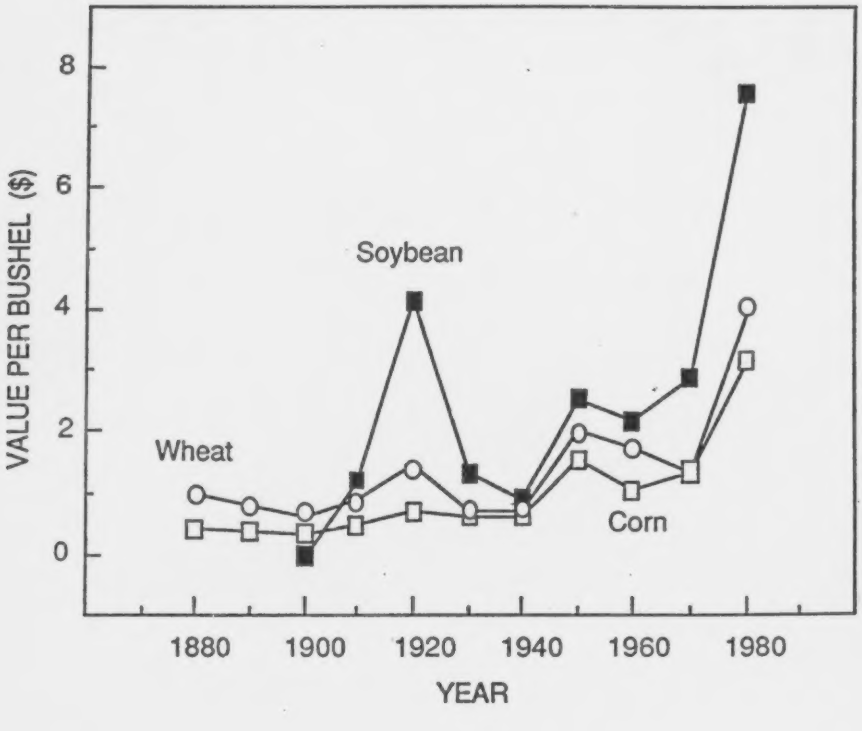
Fig. 3. Commodity value per year for wheat, soybean, and corn. 1880-1980.

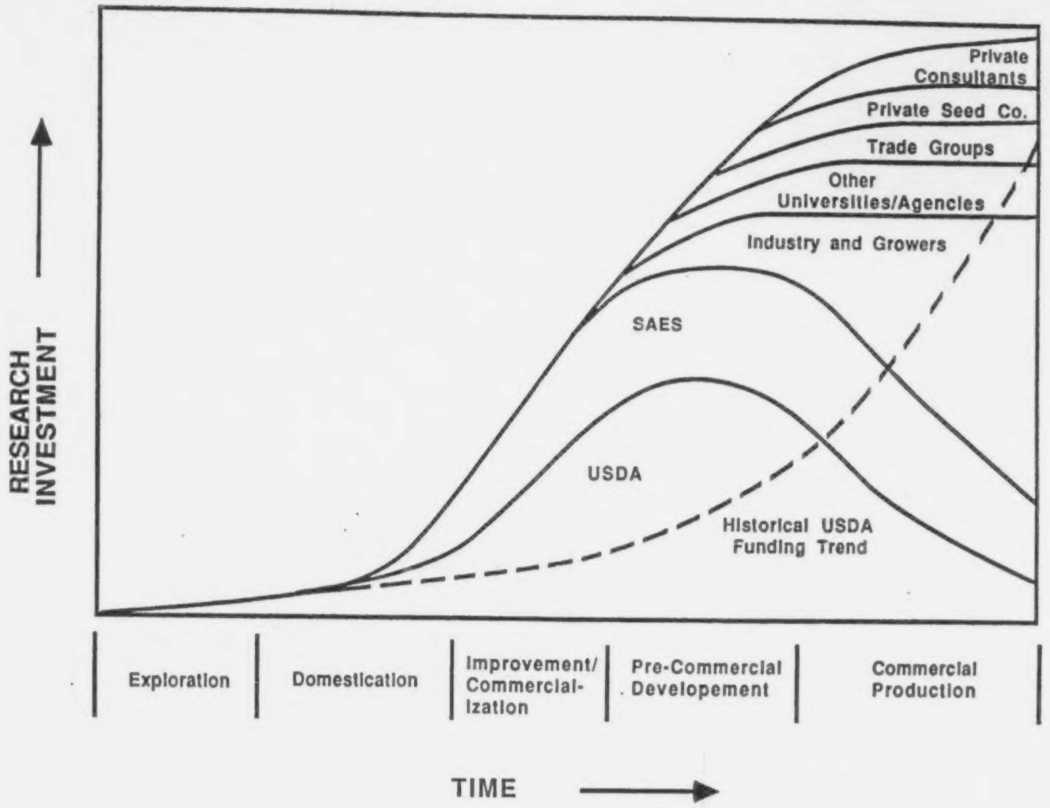
Source: United States Census of Agriculture Summary data. 1880-1981.

Fig. 4. Model of research investment strategies to support commercial development of new crops.


National Average
Highest County Average
Highest on Record
20350†
20
6
4
2
0
YIELD (1000 lb/a)
1360% Increase
340% Increase
1920
1940
1960
1980
1985
YEAR


1920
1940
1960
1980
1985


VALUE PER BUSHEL ($)
8
6
4
2
0
Soybean
Wheat
Corn
1880
1900
1920
1940
1960
1980
YEAR


RESEARCH INVESTMENT
Private Consultants
Private Seed Co.
Trade Groups
Other Universities/Agencies
Industry and Growers
SAES
USDA
Historical USDA Funding Trend
Exploration
Domestication
Improvement/ Commercial-ization
Pre-Commercial Developement
Commercial Production
TIME

THE SYSTEMATIC APPROACH TO EXPLORING ALTERNATIVES

Gary D. Jolliff
Professor of Crop Science
Leader, New-Crops Research Project
Department of Crop Science
Oregon State University

ABSTRACT

Excess production capacity is devastating U.S. and world agricultural vitality. Institutional innovation, such as a Foundation for New Farm and Forest Products, is essential to diversify American (and world) agriculture. The necessary talent, technology, and natural resources are available. Leadership, not simply management, is needed to launch a positive movement that will develop a broad-based, 'can-do' spirit. Legislation is essential to facilitate needed change. Data, graphics, examples, and discussion based on the literature references will be presented to expand on the following text.

THE PROBLEM

Enormous amounts of resources are being spent in the U.S. (and world) on agricultural commodity surplus related problems. American farmers lack profitable alternative crops although the potential for development of such crops exists. An adequate voice for new crop research and development does not exist. The huge potential annually renewable wealth base of American agriculture has been to a great extent neutralized, rather than realized. A perennial lack of focus and support for the development of new farm and forest products has resulted in widespread disillusionment, dissatisfaction, nonalignment, and ineffective use of human resources to develop this wealth.

THE POTENTIAL

The U.S. has the brainpower, the technology, and the natural resources to convert the agricultural production excess capacity from an economic, political, and social burden to an economic, political, social, and scientific asset.

THE SOLUTION

Leadership, in particular, skill beyond operational management is essential at this juncture. We must begin with leaders who understand the problem as well as the potentials for long-term solutions. They must have the conviction that people can make things happen, and that the role of leadership is to clear the way.

Prepared for pre-symposium Proceedings publication as part of the session: Approaches & Opportunities in the Development of New Crops. Symposium on Grain Legumes as Alternative Crops. Sponsored by the Center for Alternative Crops and Products. University of Minnesota. Radisson Hotel South. Bloomington, MN. July 23-24, 1987.

Such individuals must be as free as possible from personal, political, and financial conflicts of interest that might interfere with objectivity in judgement. This requires making consensus and synergy among disparate special interest groups and listening to sectors that have traditionally lacked a political voice. Appropriate leaders will be inclined to do this because they will have the future of the nation and agriculture at heart. The work they initiate must not be subject to the short term political changes which serve to keep U.S. agriculture off balance, and diverted from strategic planning.

THE MECHANISM

Formation of The Foundation for New Farm and Forest Products has been proposed to the Secretary of Agriculture as the place to start. A highly credible entity with a sharply focused mission is essential. It must be well supported in concept and resource, and protected from political interference. The necessary accountability is discussed below. Its organizational structure should facilitate full utilization of the diverse U.S. resources.

United States agriculture needs the equivalent of a "National Science Foundation for crop and product diversification."

THE RESOURCES

Government, industry, and academia would participate at the local, state, regional, national, and international levels. The new national thrust by the National Science Foundation for establishing engineering research centers serves as a model. Emphasis is on goal orientation and interdisciplinary efforts involving cooperation of government, industry, and academia, to increase U.S. competitiveness. Government agencies such as the Department of Commerce, National Science Foundation, Office of Technology Assessment, and the Department of Defense should share major implementation roles with the U.S. Department of Agriculture. Private and non land-grant universities and colleges have significant roles to share along with the nations agricultural experiment stations. Equally important is the mobilization of the entire national agribusiness community, including farmers and agricultural commodity organizations.

THE LEVERAGE

Joint ventures in risk-taking and the development of vested and proprietary interests will result in a coalescence of financial and political support. This must be led by the public sector. Secondly, multiple participants can aid in the rate of progress through the iterative and tortuous process of research and development of new agricultural crops and products. Thirdly, national attention on a focused mission for the development of new crops and products will attract interest and participation of hundreds of scientists in academia and industry around the world who have resources at their disposal. Opportunities for competitive research grants, from various agencies, can be productive in leveraging national resources. Private industry can be expected to take the lead as soon as profit potentials become apparent.

THE ACCOUNTABILITY

Joint long-term ventures by government, industry, and academia likely will provide opportunities for checks and balances beyond the degree, and of a more useful sort, than might be expected in similar projects mounted entirely within the confines of any one of the three sectors (which often have otherwise separate goals).

THE NEXT STEP

Legislation needed includes adopting a system of rules which will facilitate policy decisions to meet the above described needs. It is difficult to predict the effectiveness of initiating needed changes at the local, state, regional, national, or international levels. Since the political process is a means of cooperation aimed at achieving reciprocal advantages, it probably will be advantageous to have efforts being made for change at all levels.

INTERNAL POLITICS

People respond to incentives. Bureaucracies typically stifle innovativeness. Leaders of organizations having participants in the cooperative effort must be willing to support innovative relationships and alter some deeply ingrained political attitudes. They will recognize that outstanding achievement is an inherently uncertain process that requires continual course correction to reach the final destination (Kiefer and Senge, 1982). Employee evaluation may need special attention on long term projects in order to maintain the needed level of enthusiasm and innovativeness.

For example, course corrections made to achieve diversification of American agriculture in the shortest possible time might result in fewer refereed journal publications than if the goal were publications. Scientists employed in academia and the U.S. Department of Agriculture are very much influenced by these kinds of issues. Thus, the reward system dictates whether agricultural diversification or refereed journal publication gets priority.

Participating industries can expect that innovation from research and development personnel is often negatively influenced by pressures for profit in the short term. Like refereed publication of scholarly achievements, planning and short term economic payoffs are important, but must be subordinated to concerted, flexible effort to meet the long-term goal of diversification of American agriculture.

The Reward System

It may be necessary to develop reward systems which are specific for the goals at hand. This will require innovative leadership and management in each cooperating sector of a project. The new approach must avoid the common attitudes described so well by Kiefer and Senge (1982): "'Things don't work, and there's nothing I can really do about it. I'm dissatisfied, but I'm stuck in a system too big, too unresponsive and complex to influence, much less control.' 'Many people are no more conscious of the damage done by these hidden beliefs that they are of pollutants in the air they breathe. The beliefs quickly and easily become a negative self-fulfilling prophecy.'"

Institutional organizations in the U.S. dealing with the development of new farm and forest products have been plagued with this attitude for at least the past 35 years. Judgmentally, it is the fault of the system rather than the individual participants.

Enhanced Companionship

Public sector participants must respect and encourage private sector interests of both the vested and proprietary sort. Similarly, private sector participants should, and must, respect the publication of information which will, in the long run, most rapidly advance the state of knowledge and development of new farm and forest products for American agriculture. The American consumers ultimately will receive the greatest benefit.

THE NEW MIND-SET

Given the innovative institutional arrangement described above, it will be possible to develop a collective synergy transcending anything experienced in agriculture since the 'victory gardens' of the 1940's and the space race of the 1960's. I speak of a patriotic spirit, as manifested during past national crises. Americans rise to meet challenges. Scientists, farmers, politicians, consumers, and members of corporate America can join together to accomplish this common goal.

LITERATURE REFERENCES

Agricultural Recovery Council. 1983. Agriculture -- vital to Oregon's economy. A report to the Governor of Oregon. Oregon Department of Agriculture. Salem, OR.

Brown, J.G. 1986. Beyond the myths of agroindustries. Address to Industrial Agronomists, American Society of Agronomy, New Orleans, LA.

Center for Alternative Crops and Products Steering Committee. 1987. Center for alternative crops and products: A proposal. College of Agriculture. University of Minnesota.

Jolliff, G.D. 1987. New crops and products for American agriculture: Rationale for institutional change and strategic planning. (To be submitted to Science for publication).

Jolliff, G.D. 1983. New crops research: The orphan of American agriculture. Address to Agri Business Committee, Corvallis Area Chamber of Commerce. Corvallis, OR.

Jolliff, G.D. 1984. Meadowfoam -- a crop for tomorrow?? Proceedings of the 1984 Agricultural Conference Days. Oregon State University. pp. 101-104.

Jolliff, G.D. 1985. Reasons to participate -- in: Agriculture, U.S. crop production, politics. Lecture in Crop Science. Oregon State University.

Jolliff, G.D. and S.S. Snapp. 1987. New crop development: Opportunity and challenge. Journal of Production Agriculture. 1: (In press).

Jones, T. 1987. The essence of organization. In: Creative Living. 16(2):2-5. Northwestern Mutual Life Insurance Co. Milwaukee, WI.

Kiefer, C.F. and P.M. Senge. 1982. Metanoic organizations: Experiments in organizational innovation. Innovation Associates, Inc. Palo Alto, CA.

Mawby, R.G. 1984. Ag colleges must help end ignorance about farming. Crops and Soils. 36(9):4-6.

National Research Council Committee on Agricultural Biotechnology. 1987. Committee calls agricultural biotechnology research unfocused; recommends action toward a new national strategy. News Release. May 27, 1987. National Research Council. Washington, D.C.

New Farm and Forest Products Task Force. 1987. New farm and forest products: Responses to the challenges and opportunities facing American agriculture. A Report to the Secretary, U.S. Department of Agriculture. June 25, 1987. Washington, D.C.

Organization for Economic Cooperation and Development. 1987. Joint Report of the Trade and Agriculture Committee. To be released July, 1987. OECD. Washington D.C., Paris.

Ott, S.L. 1987. Biotechnological processing and agricultural prosperity: A historical perspective of a false promise. Journal of Agribusiness. 5:41-46. Agricultural Economic Association of Georgia and the Division of Agricultural Economics. Univ. of Georgia.

Skrzycki, C., M. Horn, L.J. Moore, S.F. Golden, N. Linnon, and P. Dworkin. 1987. Risk takers. U.S. News and World Report. January 26, 1987. pp. 60-67.

The Experiment Station Committee on Organization and Policy, and The Cooperative State Research Service, U.S. Department of Agriculture. 1986. Research initiatives: a research agenda for the state agricultural experiment stations. U.S. Dept. of Agric. Coop. State Res. Serv. Washington, D.C.

United States Senate. 1987. Senate Bill 970. 100th Congress of the United States. Alternative Agricultural Products Research Act of 1987. (To authorize a research program for the modification of plants focusing on the development and production of new marketable industrial and commercial products, and for other purposes) April 9, 1987. Washington, D.C.

LEBANON AREA
CHAMBER of COMMERCE
1040 Park Street
Lebanon, Oregon 97355
Telephone (503) 258-7164

December 19, 1986

MEETING NOTICE

FROM: Warren Beeson, Chairman

FOR: Meadowfoam Task Force

Friday, April 17, 1987
3:00-5:00 p.m.
Agricultural Production Room, LaSells Stewart Center
OSU Campus (park in lot near Parker Stadium)

++++If you are unable to attend this meeting, please call 757-1507, Corvallis Area Chamber of Commerce, and leave a message for Karen Hackworth.++++

AGENDA:

1) Welcome, introductions
2) Review of House Bill 2939 and proposal for accelerated commercial development of Meadowfoam (copies attached)
3) Discussion of progress with funding sources:
   - Federal
   - State
   - Private
4. Establish agenda for further action
5. Set next meeting date
6. Adjourn

Enclosures:

HB 2939
Proposal for Accelerated Commercial Development of Meadowfoam
Proposal for a Regional Economic Development Strategy
Copy of letter from Dr. Charles P. West to Chuck Craig

64th OREGON LEGISLATIVE ASSEMBLY–1987 Regular Session

House Bill 2939

Sponsored by Representatives AGRONS, ANDERSON, BELLAMY, BURTON, CAMPBELL, FAWBUSH, FRENCH, JOLIN, McTEAGUE, PARKINSON, PETERSON, PHILLIPS, SCHROEDER, SIDES, WHITTY, YOUNG, Senators BRADBURY, BROCKMAN, L. HILL, HOUCK, JERNSTEDT, TIMMS, TROW, Representative VanLEEUWEN, Senators KINTIGH, OTTO, WYERS (at the request of Oregon Meadowfoam Growers Association)

SUMMARY

The following summary is not prepared by the sponsors of the measure and is not a part of the body thereof subject to consideration by the Legislative Assembly. It is an editor's brief statement of the essential features of the measure as introduced.

Appropriates $_______ from General Fund to Department of Higher Education for biennial expenses of meadowfoam research at Agricultural Experiment Station at Oregon State University. Declares emergency, effective July 1, 1987.

A BILL FOR AN ACT

Relating to the financial administration of the Department of Higher Education; appropriating money; and declaring an emergency.

Be It Enacted by the People of the State of Oregon:

SECTION 1. In addition to and not in lieu of any other appropriation or moneys made available by law or from other sources, there is appropriated to the Department of Higher Education out of the General Fund, for the biennium beginning July 1, 1987, the sum of $_______. Such sum may only be expended for the payment of expenses of a meadowfoam plant breeding and improvement project at the Agricultural Experiment Station at Oregon State University.

SECTION 2. This Act being necessary for the immediate preservation of the public peace, health and safety, an emergency is declared to exist, and this Act takes effect July 1, 1987.

NOTE: Matter in **bold face** in an amended section is new; matter *[italic and bracketed]* is existing law to be omitted.

1

A Proposal for

Accelerated Commercial Development of

MEADOWFOAM

Prepared by the

Meadowfoam Development Task Force

February 1987

Submitted through
Oregon Meadowfoam Growers Association
2140 Turner Road, SE
Salem, OR 97302
(503) 585-1157

Abstract

An investment of approximately $14 million over the next 10 years is proposed to accomplish the full commercial development of meadowfoam. A conservatively projected return to the Oregon economy from this new industrial oilseed crop in the subsequent decade is $700 million in farm gate revenues and over $2 billion in total economic impact. Both direct and indirect benefits to Oregon's economy and environment are substantial and far reaching. A three-way cost shared funding mechanism involving the Oregon State University Agricultural Experiment Station, the USDA Agricultural Research Service, and a consortium of state and private sources is suggested. An initial funding period of five years and an amount of $8.2 million is requested.

I. Background and Current Situation

Meadowfoam is a native herbaceous winter-annual wildflower adapted to poorly drained soils. Industrial applications of the unique seed-oil were first suggested in 1959 by USDA chemists looking for alternatives to surplus crops. Potential areas of application include lubricants and metal treatment fluids, cosmetics, surfactants, rubber, plastics, waxes, mining, textiles, and leather.

Oregon has invested approximately 20 years and 2.5 million toward domestication and commercialization of meadowfoam. This was stimulated by the need for profitable alternatives to grass seed crops currently produced in the Willamette Valley. Meadowfoam appears to be the best available alternative crop adapted to the poorly drained soils, and it does not require socially invidious open-field burning for residue disposal and pest control.

A 1986 study sponsored by the USDA ranked meadowfoam second nationally in economic viability among the ten most promising potential new industrial crops. This potential has been recognized worldwide. As witness stand export sales of the oil and an international demand for technical information and oil samples for research and development, and attempts to negotiate for licensing exclusive rights to cultivar production.

Worldwide demand for meadowfoam oil is estimated conservatively at 106 million pounds annually. This translates into approximately 160,000 acres of viable cropping alternative for poorly drained soils in the Willamette Valley. No new specialty farming equipment investments are required. Meadowfoam provides a crop rotation bonus benefit for farmers by breaking disease and weed cycles in existing crops. The unique climate of the Willamette Valley of Oregon is a near perfect fit for meadowfoam production.

Farm-scale production of meadowfoam for small, high-value specialty markets has been underway for five years. A credible, reliable production management organization exists. Successful routine commercial-scale oil extraction and oil refining have been accomplished. Industrial interest in proprietary oil utilization research is growing. Advances in crop production technology and cultivar yield improvement are in process on a small scale. Oregon presently has the lead globally in the development of this crop. However, if work is not accelerated in Oregon to penetrate the high-volume, low unit price industrial market, meadowfoam will be developed in other regions; most likely by other nations where interest in new crop development is common and aggressive. Accelerated commercial development must commence immediately to capture the estimated $70 million annual farmgate wealth potential that meadowfoam represents.

No serious biological barriers have been identified that would impede the straightforward and rapid development of high yielding meadowfoam cultivars. Thus, careful and deliberate investment in meadowfoam research and development at this time is likely to provide substantial future returns of annually renewable wealth.

II. Potential Benefits

Successful development of meadowfoam as a major commercial crop in Oregon offers substantial benefits to both the economy and the environment.

By providing a profitable alternative crop to grass seed and cereal grain production, a meadowfoam industry would provide increased farm income and employment for the rural areas and smaller communities of western Oregon. Potential income at the farm gate is estimated at approximately $70 million annually, and this can be translated into approximately $200 million in total economic impact.

Further processing of this commodity beyond the farmgate could result in an economic impact several times that associated with farm production when value added in manufacturing associated with further processing of meadowfoam seed into oil and then oil into oleochemicals is considered. The general structure of the oleochemicals industry is shown in Figure 1. Note that there are three distinct producer groups: the raw materials (fat and oil producers), the manufacturers of basic oleochemicals, and the manufacturers of oleochemical derivatives. None of these industrial sectors are presently developed to any degree in Oregon. The emerging production of meadowfoam in western Oregon and of both the industrial and edible varieties of rapeseed in the Columbia Basin will eventually necessitate the establishment of oilseed processing facilities in the Northwest. This in turn is likely to lead to the development of facilities for the manufacture of basic oleochemicals and oleochemical derivatives.

The substantial reduction in field burning that would accompany the full commercial development of meadowfoam would have favorable effects on business location decisions in smoke impacted communities of the Willamette Valley. It would also be beneficial to recreation and tourism, particularly in the Cascades, and adverse health effects of smoke exposure to sensitive persons would be reduced.

III. Research and Development Goals and Objectives

The overall goal of the proposed research and development program is to realize the full commercialization of meadowfoam for industrial markets within the next decade. Achievement of this goal has three prerequisites that may be viewed as program objectives.

1. Development of high yielding cultivars which allow the production of crude meadowfoam oil in .50-1.00/lb price range with farmer profits of $35-50/acre.

2. Full definition, establishment, and expansion of the industrial market.

3. Maintenance of a reliable production management organization with sufficient production capacity.

These must be pursued concurrently and accomplished in a carefully coordinated and orchestrated fashion. Otherwise the establishment of a viable, stable system within the specified true frame is improbable.

IV. Program Organization and Structure, Specific R&D Elements

A cooperative program involving Oregon State University (Oregon Agricultural Experiment Station), the U.S. Department of Agriculture, and the Oregon Meadowfoam Growers Association is proposed. The program, which is shown diagramatically in Figure 2, is envisioned as comprising (1.) a varietal development program to improve yields, (2.) technical studies to fully define industrial utilization possibilities and the feasibility of an oilseed processing plant in Oregon, and (3.) a commercial market development and program coordination/oversight component. These are described in detail below:

Program Component and R&D Elements	Estimated Effort Level (Recurring FTE)
1. Varietal Development and Agronomic Research (Continuing Program)	
Responsible Group: OSU AES/USDA	
GERMPLASM: collect, catalog, store, multiply, evaluate, and provide, to plant breeders, seed of plant materials with genetic traits of value for improved meadowfoam production profit. Examples of traits currently needed include: sources of self-pollination for the alba species, resistance to the *Botrytis* fungus, sustained embryo sac viability under high temperatures, low glucosinolate content in the seed meal, increased stem stiffness, earlier flowering, higher seed oil content, and broader ranges of specific fatty acid composition of the seed oil.	0.5
GENETICS: develop populations of genetic materials with desired traits, determine the inheritance of those traits and design breeding strategies to develop improved cultivars for higher profitability in meadowfoam production.	0.5
PHYSIOLOGY OF YIELD (adaptation and crop modeling): study meadowfoam growth and development in detail in a standardized way to reveal the weak and strong points in its adaptation so that its production potential can be realized. These results will be useful in crop management as well as in the search for, and screening of, genetic variation for use in meadowfoam cultivar yield improvement.	1.0
PLANT BREEDING: introduce, select, hybridize, develop, test, increase, release, and monitor progress on large numbers of genetic materials to develop elite germplasm and high yielding cultivars for more profitable meadowfoam production. This	1.0

effort will use results from research in the areas of germplasm, genetics, crop physiology (modelling), oil chemistry, pathology, and other pertinent disciplines.

AGRONOMY: develop production system recommendations for meadowfoam growers to optimize yield for maximum profit. Evaluate cultivars and practices related to tillage, seeding, fertilizer applications, pest (weed, insect, and disease) control, pollinator management, and harvesting. Methods in current use as well as new technology need to be developed by specialists (e.g. weed control, seed technology, soil science, and others mentioned herein).	1.0
OIL CHEMISTRY: monitor oil content and oil quality of genetic material used in meadowfoam cultivar improvement and marketing.	0.2
PATHOLOGY (Botrytis cinerea control): determine how to reduce the meadowfoam growers' risks associated with Botrytis fungus damage. Evaluate the potential for identifying and incorporating genetic resistance to Botrytis. Investigate management techniques for the control of Botrytis on susceptible cultivars.	0.5
POLLINATION BIOLOGY: define the most profitable pollinator management strategies for use in commercial meadowfoam production.	0.2
EMBRYOLOGY: develop practical methods for rapid monitoring and screening of meadowfoam germplasm for differential sensitivities of the embryo sac to temperatures which jeopardize seed production.	0.2
TAXONOMY: develop detailed morphological and chemotaxic characterization techniques, procedures, and standards (using currently available improved materials) to facilitate plant variety protection of meadowfoam genetic materials.	0.2
BIOTECHNOLOGY: refine techniques for meadowfoam propagation from tissue culture. Provide populations of uniform progeny of cross pollinated meadowfoam for use in controlled experiments, variable germplasm for selection, and insight into meadowfoam mechanisms.	0.25
EXTENSION AGRONOMY: provide liaison among researchers, county agricultural extension agents, meadowfoam growers, and the public.	0.2

ECONOMICS: evaluate expected changes in the cost of seed and oil production with potential changes in seed and oil yields and as a result of changes in agricultural practice associated with the development of different cultivars.	0.1
RESEARCH COORDINATION: provide leadership in stimulating and coordinating oral and written communication among meadowfoam researchers, especially among those who are not required to interact to conduct their respective investigations.	0.2
MEAL UTILIZATION: make preliminary assessment of meal detoxification possibilities. Scope out entire effort involved in obtaining clearance to feed. Review previous feeding studies. Determine fertilizer value. Accelerate effort with flexible use funds if overall assessment indicates.	0.1
FLEXIBLE USE FUNDS: retain 0.5 Scientist Year equivalent funding as uncommited resources which can be used on short notice to address unexpected problems, take advantage of unexpected expertise or facilities, or in other ways enhance the commercialization of meadowfoam.	0.5
	6.65

2a. Industrial Utilization Study
(identifies specific cost competitive industrial applications for meadowfoam oil)

Non-recurring two-year study

Responsible Group: USDA-NRRC, Private Contractors, OMGA

1) Optimize extraction refining procedures	.15
2) Identify potential oil use and users	
3) Synthesize oil derivatives	1.25
4) Document properties of derivatives	
5) Distribute samples and technical information to industry, maintain liaison	.15
6) Make visitations and presentations to potential users	.15
7) Collect product performance data and processing /commercial cost data	.55
8) Develop integrated body of knowledge on the potential uses and economics of meadowfoam oil	.15
9) make recommendations for varietal development	.1
	2.5

(Cost and effort level estimates provided by Resin Research Laboratories, Newark, NJ. Estimated Cost $375,000 based on 2.5 scientist years effort @ $150,000/scientist year.

b. Oilseeds Processing Facility Feasibility Study. (Analyzes optimum size, location, costs of operation, environmental considerations for oilseed crop development scenarios in Pacific Northwest.)

Estimated Cost $60,000 (cost estimate by Johnson & Lofts, San Francisco).

3. Program Management and Coordination (recurring program)

Responsible Group: Oregon Meadowfoam Growers Associaton

a)	Lead role in promotion and advocacy	0.25
b)	Program management, coordination, facilitation, strategy development, cooperative info network.	0.5
c)	Market development activities, incl. sample and info distribution, industry visitation and liaison, development of exhibits and presentations for conferences and trade shows. Develops expanded specialty market to support short term commercial scale production.	0.5
d)	Incorporates improved varieties and cultural practices into commercial production.	
e)	Maintains capacity and state of readiness for commercial production.	
	Total	1.25

Estimated annual recurring cost $125,000 based on $100,000/staff FTE.

V. Resource Needs and Budget (Thousands of Dollars)

Annually Recurring Costs

7 Scientist Years per year at 150	1050
1.25 Full Time Equivalent Staff (Oregon Meadowfoam Growers Association)	125
Total Recurring	1175

One Time Investments

*Facilities	1462
Industrial Utilization Study	375
Oilseed Processing Facility Study	60
Oil Inventory (100,000 lbs)	400
Total One-Time Investment	2297

Totals

Total for 1987-88	3472
Total Recurring per year 1988-89 through 1991-92	1175
Grand Total for Ten-Year Period 1175 x 10 years + 2297 (one-time investment)	14047

*FACILITIES

These are preliminary estimates based on new USDA facilities constructed at Oregon State University in 1986. Further refinement may be needed.

Greenhouse	790
Headhouse	180
(5) Controlled Environment Chambers (PGV-36)	200
Contingencies	117
Planning	117
Supervision	58
Total	1,462

VI. Proposed Funding Mechanism and Schedule

It is proposed that costs be shared equally by the following three sources:

a. Oregon State University and the Oregon Agricultural Experiment Station

b. United States Department of Agriculture, Science and Education Administration, Agricultural Research Service

c. A consortium of interested parties potentially including:

1) Oregon Meadowfoam Growers Association (oil inventory)
2) Oregon Department of Environmental Quality, Field Burning Research Advisory Committee
3) Oregon Resource and Technology Development Corporation
4) Advanced Science and Technology Institute (OSU and U of O Cooperating)
5) Oregon State University Foundation
6) Agricultural Research Foundation (OSU)
7) Oregon Department of Agriculture
8) Oregon Department of Economic Development
9) E. R. Jackman Foundation
10) Several Chemical Companies
11) Oregon New Crops Development Board
12) Oregon Agricultural Commodity Commissions

However, the one-time expenditure for facilities (1.5 million) probably would require legislative appropriation.

Only the first 5 years of funding is being requested in 1987. The proposed funding matrix is as follows:

SOURCE OF FUNDS	AMOUNT OF FUNDS (Thousands of Dollars)				
	1987-8	1988-9	1989-90	1990-1	1991-2
a. Oregon State Univ. and Oregon Agric. Experiment Station	670	392	392	392	392
b. USDA-SEA-ARS	670	392	392	392	392
c. Consortium	670	392	392	392	392
d. Oregon legislature	1462	000	000	000	000

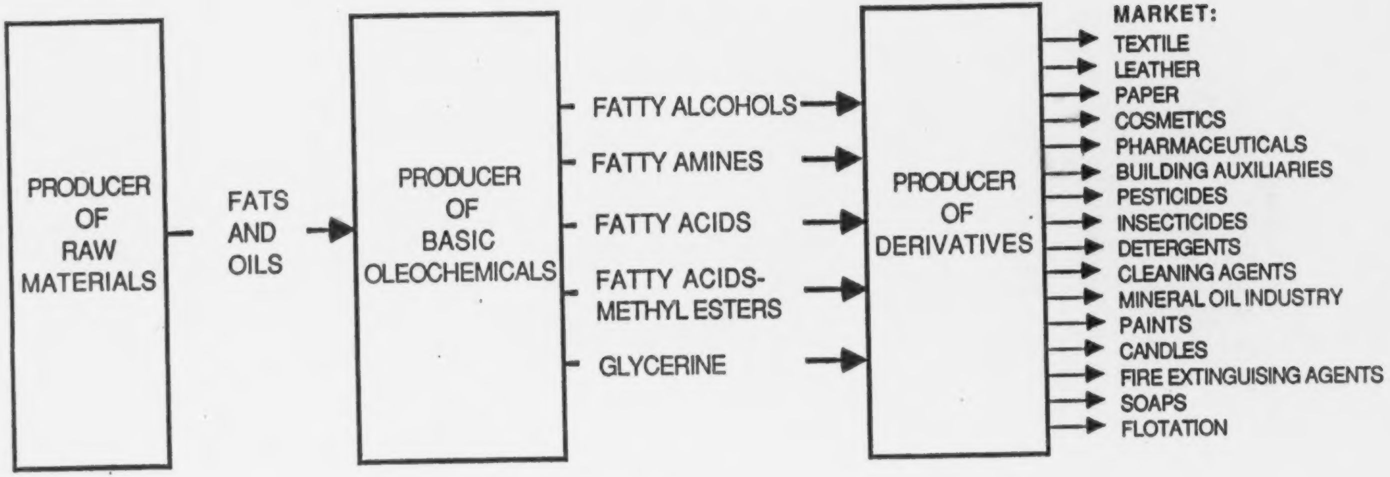
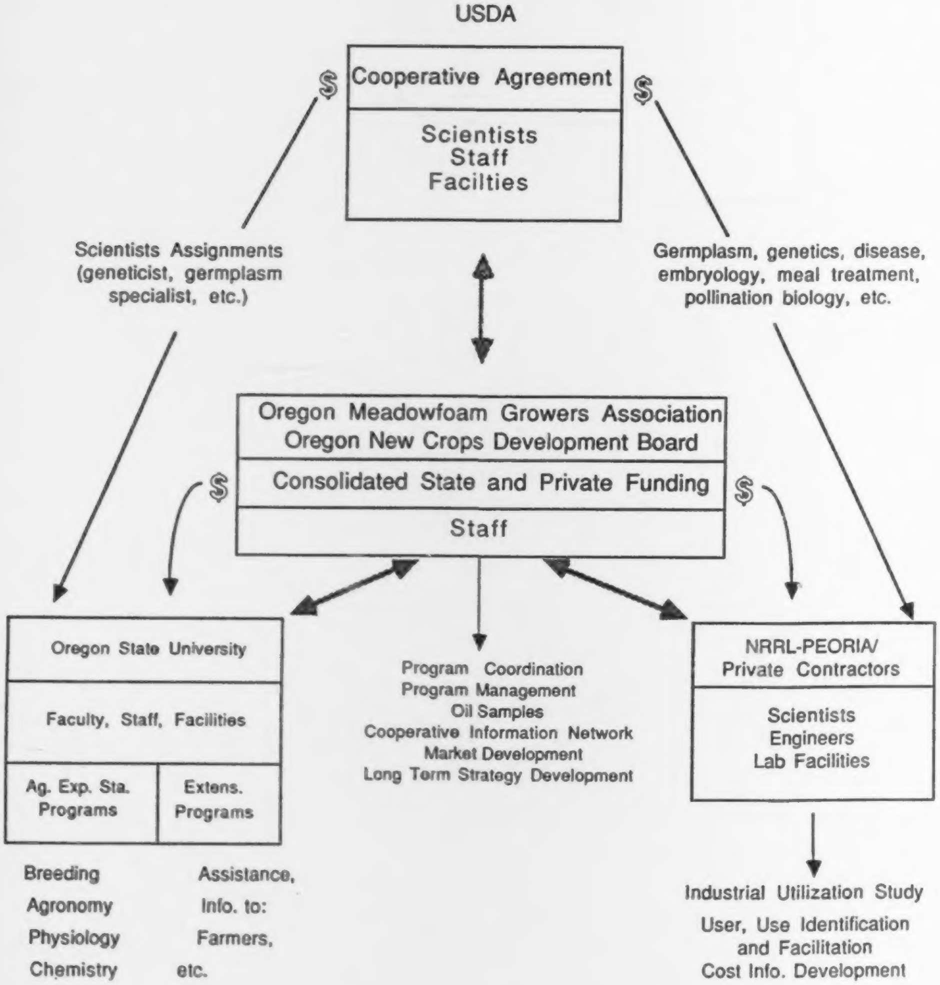

PRODUCER
OF
RAW
MATERIALS
FATS
AND
OILS
PRODUCER
OF
BASIC
OLEOCHEMICALS
FATTY ALCOHOLS
FATTY AMINES
FATTY ACIDS
FATTY ACIDS-
METHYL ESTERS
GLYCERINE
PRODUCER
OF
DERIVATIVES
MARKET:
TEXTILE
LEATHER
PAPER
COSMETICS
PHARMACEUTICALS
BUILDING AUXILIARIES
PESTICIDES
INSECTICIDES
DETERGENTS
CLEANING AGENTS
MINERAL OIL INDUSTRY
PAINTS
CANDLES
FIRE EXTINGUISING AGENTS
SOAPS
FLOTATION

Figure 1. General structure of the fats and oils industry.

Figure 2. Cooperative Program to Accelerate Commercial Development of Meadowfoam


USDA
Cooperative Agreement
Scientists
Staff
Facilties
$
$
Scientists Assignments (geneticist, germplasm specialist, etc.)
Germplasm, genetics, disease, embryology, meal treatment, pollination biology, etc.
Oregon Meadowfoam Growers Association
Oregon New Crops Development Board
Consolidated State and Private Funding
Staff
$
$
Oregon State University
Faculty, Staff, Facilities
Ag. Exp. Sta. Programs
Extens. Programs
Breeding
Agronomy
Physiology
Chemistry
Assistance, Info. to: Farmers, etc.
Program Coordination
Program Management
Oil Samples
Cooperative Information Network
Market Development
Long Term Strategy Development
NRRL-PEORIA/ Private Contractors
Scientists
Engineers
Lab Facilities
Industrial Utilization Study
User, Use Identification and Facilitation
Cost Info. Development

PROPOSAL FOR A REGIONAL
ECONOMIC DEVELOPMENT STRATEGY
LINN COUNTY, OREGON
Feb. 1987

GOAL: Restore prosperity to the region's agricultural sector economy by development of a new alternate crop, meadowfoam. Related benefits of this will accrue to the tourism industry, retirement development industry, industrial recruitment efforts and in the health care industry.

PROPOSAL: Provide one-time funding investments of $1,462,000.00 by the state to establish the project and support annually renewing costs of approximately $1.25 million (combined private, state and federal) for a ten year period. Efforts would accelerate development so that significant commercial returns would result in 5-10 years.

BENEFITS:

1) Provides PROFITABLE alternate crop to grass seed for farmers
2) Potential for value-added industry in processing, refining, manufacturing and transportation
3) Could eliminate 100,000-150,000 acres of grass crop annually, decreasing field burning requirement, meadowfoam fields do not require burning
4) Provides $70 - 80 million farmgate return - annually renewable new-type of product that is unique
5) Taps existing resources at OSU, State Dept. of Agriculture
6) Has REGIONAL impact
7) Has economic development impact on several sectors, eg. tourism, health care, retirement
8) Provides additional value to remaining grass seed crop through reduction in production (supply)
9) Restores balance and diversity to region's agricultural products
10) Provides new options for farmers and industry
11) Elicits broad-based community support
12) Capitalizes on approximately 15-25 years of previous development

SUMMARY: This proposal is a unique economic development opportunity because: it restores viability to one of our traditional economic resource bases; it provides economic diversification opportunities to a broad range of industries and commercial enterprises; it will produce results in an acceptable time span; it will produce esthetic, health and public benefits as well as economic benefits; it will utilize public and private funding sources, and; it fulfills requirements of good public policy on a state, local and national level.

Resin Research
Laboratories Inc.

26 Avenue B
Newark, N.J.
07114
201/242-6500

March 3, 1987

Mr. Charles D. Craig
Oregon Meadowfoam Growers Assoc.
2140 Turner Rd., S.E.
Salem, Or. 97302

Dear Chuck:

I reviewed your proposal for the accelerated commercial development of meadowfoam with great enthusiasm.

As you know Roger Gaire and I have been acting in the capacity of consultants to the USDA-Office of Critical Materials. Recently we issued a report entitled

"TECHNICAL, ECONOMIC AND MARKET ASSESSMENT AND STUDY OF AGRICULTURAL MATERIALS AS INDUSTRIAL FEEDSTOCKS".

In this study we examined the potential viability of the 10 most promising new crops candidates.

We have recently updated our findings. In our opinion meadowfoam and rapeseed deserve the highest priority for accelerated commercial development efforts.

Our conservative estimate of the market potential for meadowfoam oil if it were available in the $.50-$1.00 a pound range is 100MM pounds and maybe as high as 300MM pounds annually. Only an in depth industrial utilization study such as you have proposed can pin this down closer.

Meadowfoam oil aside from its use in cosmetics has the following potential:

- Flotation agents for ore seperation. Emphasis on critical metals needed for industry and the national defense.
- Compounds based on meadowfoam for high performing lubricants.

Mr. Charles D. Craig --2
March 3, 1987

- o Compounds for the processing of rubber and plastics.
- o Compounds to replace the toxic PCB material used in electric transformer oils.
- o The potential of the development of a weather resistant epoxy plastics.

Meadowfoam shows great promise as an industrial feedstock. Your well written proposal clearly and correctly identifies those areas of research which need to be completed to make this a reality.

Chuck, Oregon is in a lead position to seize the initiative and capture a rare opportunity that should pay handsome returns for decades to come.

I hope that the Oregon Legislature, the USDA and other involved parties see this and act positively.

Very truly yours,

Charles P. West

Charles P. West, Ph.D.
President

CPW:vs

NEW CROP

OILFIELDS OF THE FUTURE

A winter-sown oilseed crop, meadowfoam, which produces very high quality oil was grown on commercial scale by farmers in the USA for the first time this year. It is hoped it will soon be grown here, writes Edward Long.

Mr Jerry Mullen "Meadowfoam is easy to grow."

MEADOWFOAM has been developed from a herbaceous annual weed of temperate grassland. It is a native of the west coast of the USA and Canada, and is commonly found in British Columbia, Vancouver Island, Oregon and the uplands of northern California. It is closely related to the UK garden plant, Limnanthes douglasii — poached egg.

The crop was "discovered" many years ago but it was only in the late 1970s that the development work hotted up. It was originally found by US Department of Agriculture scientists searching for new sources of industrial oils.

They spotted the unique composition of meadowfoam oil, which contains more than 95 per cent of fatty acids with long carbon chains, making it ideal for a range of industrial uses.

It is very similar to sperm whale oil, which is in great demand by the Japanese cosmetics industry. Oriental women use a lot of make-up and in the past sperm whale oil formed the base of many commonly-used products. But current restrictions on whaling around the world are causing problems for the lipstick and facial cream makers of the east.

"The Japanese are taking a lot of interest in our oil," says Dave Nelson of the Oregon Meadowfoam Growers Association whose members grew 200ha (500 acres) of the crop in 1985.

"We sold oil worth 32,000 dollars to Japan earlier in the year and we are hoping this will lead to a huge export demand. As well as going to make cosmetics, it could also be used in the textile and plastics industries.

"Many multi-national oil companies are also checking on its lubrication qualities, as it could be used in transmission systems and as an additive in a wide range of oil products."

As meadowfoam oil is easily converted into a liquid wax it could claim some of the market currently being met by oil from the desert bush, jojoba, used in health and beauty products.

Although the big push towards commercialisation of meadowfoam only came a few years ago in the US, behind-the-scenes work had been carried out by plant breeders at Oregon State University at Corvalis. They produced the variety which formed the basis of the 1985 crop, Mermaid.

This variety grows on almost any soil except perhaps the lightest sands. It is normally sown in October and by early to mid summer it develops a solid canopy of foamy white flowers on erect stems about 30cm (12in) tall.

Experience so far suggests that following a well fertilised crop no additional N, P or K is needed.

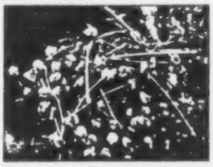
In Oregon the crop is sown at a rate of between 33 to 44kg a hectare (30 to 40lb an acre) on 15cm (6in) wide rows. The university advisers say closer rows provide quicker ground cover to smother weeds. Otherwise propachlor (Ramrod) can be used pre-emergence to control broad-leaved weeds with a post-emergence dose of diclofop-methyl (Hoegrass) to knock out grass weeds.

Meadowfoam needs bees and other insects for pollination. Bees love the crop and are attracted from miles around. If they do a good job, as many as five seeds develop in each head and these are ready for harvesting in early to mid-July in Oregon.

Seed losses are lowest if the crop is swathed when 90 per cent of the seeds are mature. It can then be picked up seven to 10 days later.

According to the university, the best yields range from 866 to 1756kg a hectare (7 to 14 cwt an acre). But it is hoped to boost yields to between 2·7 and 3·3 tonnes a hectare (22 to 27 cwt an acre).

The seed, about the size of a large clover seed, contains between 25 per cent and 30 per cent oil. At the moment the value of the oil is about on a par with rape oil and, with yields as low as half a tonne an acre, the economics look poor. But if the new markets develop the oil would be worth 2½ or even three times as much and become competitive here.



One Oregon farmer who has grown meadowfoam in 1985 is Mr Jerry Mullen, who farms 128ha (320 acres) of light to medium loam at St Paul, near Salem. He is one of 22 farmers who have each paid 1000 dollars (about £700) to form the Oregon Meadowfoam Growers Association, to promote and market the crop.

"This year is the first time meadowfoam seed has been available for commercial production and I decided to try 20 acres," Mr Mullen says. "We desperately need a new crop and I have a similar acreage of evening primrose this season."

The meadowfoam followed winter wheat in the rotation. After the straw was removed, the stubble was ploughed to a depth of 30cm (12in) and a fine seed bed was prepared. With small seeds the crop needs a fine tilth and must not be sown deep.

"I was told that the crop is a good scavenger of nitrogen and that no fertiliser was needed. But I applied a little liquid N, P and K at drilling to get it off to a good start. I also put on 80 units of nitrogen in March but the crop probably did not need it," says Mr Mullen.

The crop was put in with a grain drill at a rate of 16kg a hectare (15lb an acre) on 15cm (6in) wide rows. Mr Mullen says it needs a cold spell after drilling to trigger vernalisation. It germinated well on his farm last autumn.

At planting, propachlor was used to keep the crop free from broad leaved weeds and later fluazifop-butyl (Fusilade) was sprayed to get rid of wheat volunteers.

The crop grew vigorously and at about half bloom, in early May, a dose of vinclozolin (Ronilan) fungicide was sprayed to control botrytis grey mould.

In July the crop was windrowed and when it was harvested five days later Mr Mullen ended up with a yield of 1·25 tonnes a hectare (10cwt an acre). The crop was grown on contract to the association at a price fixed for 1985 at 75 cents a lb.

"Meadowfoam is easy to grow and I am optimistic that we are on the verge of a real crop. We just need the breakthrough with the marketing and we could be away," he says.

Oil from the Oregon crop has been tested in this country by a specialist oils company, the Hull-based Croda Universal.

"The oil is certainly unique and we are happy we can convert it into useful products for all sorts of industrial uses," says Croda's Keith Coupland.

"We are also happy we could crush the seed but the crop is not 'a goer' as far as we are concerned if we have to import it from the US. We need a reliable source of supply from the UK at a delivered-in price that only British farmers could meet."

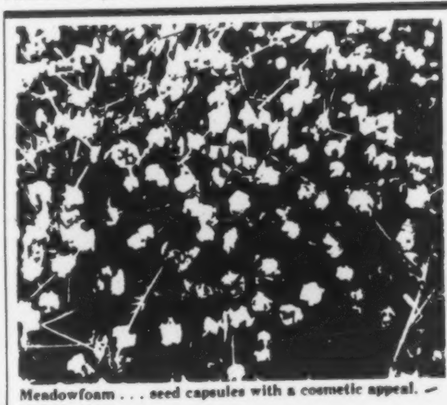
Mr Coupland says meadowfoam has "a lot going for it" as it is a renewable source of a very high quality oil. Europe is a net importer of oils and fats and more European production of the right crop is needed.

"Meadowfoam is a real candidate as there is a ready market for its derived products," Mr Coupland points out.

Next year East Anglian seeds merchant, Kings of Coggeshall, plans to grow meadowfoam on its trials ground. If the crop develops here it could be grown on contract with farmers through Kings' subsidiary company, Bio Crop Associates.

Farmers Weekly, March 28, 1986

Europe is calling out for more meadowfoam



Meadowfoam . . . seed capsules with a cosmetic appeal.

A MARKET HAS OPENED UP for a high quality meadowfoam-like oil in Europe — but unless yields are increased and the price is similar to rape oil, this new market is likely to be supplied by other sorts of oil.

Developed from a herbaceous annual weed of temperate grassland, the new crop is being commercialised by the Oregon Meadowfoam Growers Association, a grower-run organisation set up to promote the crop.

Last July, meadowfoam, a winter-sown oilseed crop of 200ha (500 acres), was harvested commercially in Oregon on the west coast of the USA for the first time.

Oil from the Oregon crop has been sold to Japan to see if it is suitable for the huge Japanese cosmetics industry. It could also be used in the textile and plastics industries and many of the multinational companies are checking its lubrication qualities.

Last year's US crop yielded around 1·25 tonnes/ha (10cwt/acre).

Oil from the Oregon crop has been tested in this country by Hull-based Croda Universal.

Croda director Keith Coupland confirms that the oils is of "super" quality and says there are ready markets for it in Europe — at a price.

"The Oregon Meadowfoam Growers Association has been to see us but its expectation and ours are poles apart," Mr Coupland explains.

"The oil yield an acre is low and a high price is needed to justify the crop.

"But with present market outlets the price needs to be about the same as rape oil. The Oregon people are hoping for a higher value market, such as the cosmetic trade," says Mr Coupland.

Senator CONRAD. Thank you for your presentation.

We will now open it up to questions for all of the panel.

You outline an ambitious program for the United States; a significant departure from the way that we have proceeded in the past, and frankly one that I agree with; but it does not mean we are going to be able to easily sell this program because what we are talking about is the creation of a trust fund, an accommodation that would be involved in the agriculture research function, changing the direction of research.

As I understand it, the $1 billion; $200 million a year that would come from the sale of CCC commodities. I want to tell you that I will be involved in developing a bill to implement your recommendations. I think it is the most exciting prospect that agriculture has for the future, that I have seen in a long time; and I think it has the potential to bring us real rewards.

Let me ask you this: We, traditionally, as has been pointed out in your testimony, Dr. Jolliff, had a funding mechanism that led to relatively low front-end funding by the Government. What do you anticipate would come from the Foundation; how would that be different in terms of how the Foundation were to operate, and who would control the Foundation?

Dr. SAMPSON. Well, Mr. Chairman, if I may begin to respond to that question, I guess the character of it is this is a publicly funded nonprofit organization, which would be report able to a board appointed in the proposed legislation that has broad representation from the community and Government.

Senator CONRAD. Public-private.

Dr. SAMPSON. Exactly. Participation from both sectors is vitally important. There is no attempt whatsoever to want to make an independent entity that can go off in some direction and be unaccountable for; there is a matter of public trust and public funds that need to be accommodated in traditional ways, but what we seek to do is insulate it from the kind of pressures that would lead it to make decisions that are not in the long term interests.

We want to have it not only accountable for proper spending of moneys, but accountable for results. And again, it's a market-oriented kind of program; and that's very key. The Government normally isn't in the business of making and selling products. It is a vehicle to bring together a new partnership between the private and public sectors.

As I pointed out in my prepared statement, it is key that the funding for this be leveraged with private sector funds. You can look at it as the Government providing seed capital. Although it sounds like a pun, seed capital is a term that refers to very early stage risk investments when you don't have all of the information that says how good a risk or how much risk is involved.

That is when you move into a venture capital stage where things are more defined. It is at the very early stage when things are very ill-defined.

Senator CONRAD. What are we talking about in terms of the mix between basic research and commercial research, if you will? What I hear you saying is that what we desperately need is an infusion of capital into that part of the research chain that is really the commercial part of the process. Am I hearing you correctly?

Dr. SAMPSON. Yes, it is the bridging between the basic research which this will overlap with but not replace; we are talking about the basic research going on in the Agriculture Research Service, the Agriculture Experiment Stations all across the country. This doesn't replace that, but it is moving that research into relevant market areas and into commercialization, and it is that bridging mechanism that needs to be covered.

Again, under a leveraged method, bringing private sector funds as well into the process. That is the point of the exercise: not only to leverage the money, but to make sure that the market relevance is there.

So I guess, in my view, innovation is a continuum. It goes from research to development of a product and commercialization of a product. The problem in history teaches us that you cannot treat it as discrete steps. The comment was made earlier to a reference I stated yesterday with regard to baton passing. You cannot look at the process of innovation as technological baton passing: where you start from research, and you pass it off to someone else, who will then do something with it. It doesn't work that way; history tells us over and over again it has to be a partnership right from the beginning. That doesn't replace the need for research, but you need to start involving people in the process, in developing partnerships that are going to last through the whole process.

Senator CONRAD. Let me just take a moment here, because we have a vote on the floor. We could do one of two things: We could leave now, go over, vote and return, or we could kind of push this thing to the limit in terms of getting to the vote, and have a chance for a brief summary statement from each of you.

Senator Karnes, do you have any strong feelings on this?

Senator KARNES. No. As a corn farmer, I just appreciate hearing what you folks were saying. We have a crazy day going today, so I do not want to inconvenience you folks. I appreciate your testimony.

Mr. Chairman, you can proceed as you wish.

Senator CONRAD. I think perhaps the best thing is if we take a quick concluding statement, because it may well be that once we get to the floor we will have one vote and have another vote quickly follow, in which case you would be inconvenienced quite a bit. So if we can do that.

Dr. BENTLEY. Mr. Chairman, we will do whatever you wish.

I would want to, before we left, be sure that we recognize several members of this task force, and I must say they did an outstanding job. Some are here today, and they are in the group here.

Senator CONRAD. Well, maybe we could introduce the other members of the task force. Dr. Sampson, if you would do the honors, we could have those who are here be introduced and stand. We would very much like to enter that into the record.

Dr. SAMPSON. Yes, thank you, Mr. Chairman.

There are a number of people here in the audience. We have Mr. Charles P. West, from the private sector; right behind him is Dr. Melvin G. Blase, department of agricultural economics, University of Missouri; Mr. Robert J. Gaire of Foster Wheeler USA Corporation, in the private sector again; Dr. William F. Stoll, technical college, University of Minnesota Technical College, Waseca; Dr. Michael Ladisch, A.A. Potter Engineering Center, Purdue University; Mr. Robert J. McCoy, the Procter & Gamble Company; and we have a number of the many people who are members of the USDA secretariat with us. Dr. Richard Wheaton, Office of Critical Materials, and Dr. David B. Johnson, Forest Service, are here, too.

Senator CONRAD. Let me just once again thank all of you. I think this is simply an excellent piece of work. We have had a chance to review it, talk about it with my staff. I think this is an extraordinarily helpful effort that you have made which points the direction that we ought to be following for the future, and this is exciting. There is an enormous opportunity out there, and I think you have pointed the way.

As I indicated, I intend to pursue it. I hope that we are able to persuade my colleagues this is the direction we ought to be taking for research in agriculture. I firmly believe in the public-private partnership aspects you proposed and the targeting of our research in those areas where we could really make a difference.

So again, thank you very much.

Senator KARNES. I just wanted to thank the Chairman publicly for his interest in this area, and also acknowledge for myself that this indeed should be a priority, a national priority. We have tremendous resources, not only of human capital but also of creative capital and financial capital in this country. I believe channeling that to a larger degree into this area would not only make our country more competitive—that's a buzz word now, competitiveness—but also it would create opportunities for those great folks out in the Midwest and throughout our country that Kent and I represent; but also I think it would put forward a very strong endorsement that our country will be competitive long term with a renewable resource, hopefully, which has been the base of our country's success I think over the last 200 years; that is agriculture.

Thank you, Mr. Chairman.

Dr. BENTLEY. Mr. Chairman, I have one more item. Professor Ladisch has done some work—he has a chemical engineering background at Purdue University—on drying ethanol and using corn as the basis for it. He did not make a comment. I would hope that the subcommittee would accept a report. It is part of one of the success stories they have.

Senator CONRAD. We would be more than pleased to do that. Dr. Ladisch, if you could provide us with that, we will enter it into the record of this hearing as an example of one of the successes. We will be glad to do that.

[The material of Michael R. Ladisch can be found on page 333.]

Senator CONRAD. Again, I want to thank all of the witnesses. I think you have been very helpful to us. We now have to dash to the floor because we have 7½ minutes.

[Whereupon, at 11:55 a.m., the subcommittee adjourned, subject to the call of the Chair.]

[Material submitted for inclusion in the record follows:]

Testimony for the Subcommittee on Agricultural Research

submitted by

Michael R. Ladisch
Laboratory of Renewable Resources Engineering
Purdue University
West Lafayette, IN 47907

Corn grits remove water from ethanol on a commercial scale to process approximately 800,000 gallons/day of fuel alcohol at the ADM Corporation at a cost savings of about 4 cents/gallon. This technology, developed at Purdue University and first commercialized by ADM, requires less than 2000 Btu/gallon of 92.4% (by weight) ethanol processed to obtain a 99.6% fuel grade alcohol. Laboratory and pilot-scale studies show that the ground corn will selectively adsorb water to give substantially water-free product from ethanol vapors containing between 1.6 and 50% water. When packed in a fixed-bed configuration, the corn also stores the heat of adsorption in a zone immediately adjacent to where water adsorption has occurred. This heat can be used to help dry the grits during regeneration, hence, contributing to the energy efficiency of this process. Substantially water-free product also results when water containing vapors of n-propyl, isopropyl, methyl, and t-butyl alcohols are passed over previously dried corn. Combined with low cost (at about 10 cents/lb) and operational stability, these characteristics provide an example of the versatility of a corn product and its potential as an adsorbent for industrial manufacturing industries.

Rapid process scale-up of this new and energy efficient approach to removing water from alcohol was made possible by a productive university/industry interaction to accomplish technology transfer. Elements include: a strong engineering tradition; resources for carrying out high risk fundamental research; a laboratory environment conducive to fundamental research which, if successful, addresses important practical problems; an entrepreneurial spirit at both the university and the company; the willingness for all involved to undertake risk to field a new process for which there is only a limited experience and research base; and perseverance. In this particular case, the various elements required came together in an appropriate manner at the right times and the right places to result in rapid research and development of this technology and transfer of this technology from a laboratory setting to commercial use in about 5 years.

This technology for drying alcohol can reduce ethanol production cost by reducing energy costs associated with the last distillation step to remove water from ethanol. In this context the technology may make a contribution for increasing the amount of corn used in producing a non-leaded octane booster, ethanol, and thereby help to expand new markets for corn. The rapid development and application of new bioprocessing technologies for converting renewable resources and agricultural output to value-added products requires a strong fundamental research effort combined with effective technology transfer from the university setting into industry.

I would like to acknowledge the support for this work through grants and contracts from the U. S. Department of Agriculture as well as the National Science Foundation, the State of Indiana and Purdue University, the State of Indiana Energy Development Board, the Department of Energy (SERI), and the Archer Daniels Midland Corporation.

CENTER
FOR
ALTERNATIVE CROPS AND PRODUCTS

College of Agriculture
University of Minnesota

Table of Contents

I. Introduction

II. Mission Statement

III. Current Status of the Center

IV. Concepts of the Center

  A. Objective

  B. Purpose

  C. Organization

  D. Ways and Means

V. Sponsored Symposia

VI. Sponsored Research and Development Projects

  A. Idea Generation, Receipt and Evaluation

  B. Action on Successful Preproposals

  C. Dissemination of Information and Recommendations

  D. Idea Development Procedure Summary Flow Plan

VII. Criteria for Measuring and Evaluating Success

VIII. Present and Projected Resources

IX. Classification of Expenditures for 1986-87 to 1991-1992

X. Ranking of Priorities at Current Funding

XI. Funds Possibly Available for Reallocation

XII. Priorities with Increase Funding

XIII. Impact on Space, Computing Capacity, Other Programs and Libraries

1-2

I. Introduction -

Currently the agricultural economy in Minnesota and the upper midwest is experiencing many economic difficulties. A significant portion of this problem involves the relatively narrow base of crops and products. The University of Minnesota, College of Agriculture, is to many a source of information and help and is expected to respond. To date, little organized effort has been devoted to providing a structured, rational response to this demand. The Center for Alternative Crops and Products provides this voluntary, multidisciplinary, problem-solving commitment with the necessary assistance to develop and fund projects. Additionally, the Center is developing a data base of information from the scientific community through sponsored symposia and assimilating existing information not generally accessible. As to the public need, the Center also functions as a contact point at the University.

II. Mission Statement -

The Center for Alternative Crops and Products explores new crops or new uses of existing crops as agricultural alternatives. It serves as an integrated market-driven forum for systematically investigating the economic feasibility of growing and processing crops and new products in the Upper Midwest. The Center performs the following tasks:

A. Receives proposals for alternative crops and products and evaluates their economic and technical feasibility.

B. Supports and coordinates research and development into alternative crops that seem feasible.

C. Disseminates research and development information to concerned organizations and individuals and provides liaison between users of this information.

The Center is composed of individuals from the university, industry and public agencies interested in working cooperatively on Center activities and assisting in the achievement of goals and objectives.

III. Current Status of the Center -

The concept of the Center for Alternative Crops and Products was discussed by the department heads in the College of Agriculture in early 1986 and a Steering Committee was appointed in July 1986. That committee has met regularly to date concentrating on process, policy and organizational structure. The activities currently in place include:

A. The first in-depth symposia is being planned for late July or early August 1987 through the Office of Special Programs.

B. A Center brochure is being developed.

C. A grant proposal has been submitted to the Governor's Rural Development Council for $10,000.

D. The Administrative Board and the Consultative Panel will be organized in the very near future.

E. Response is being made to parties who have ideas and have learned of the Center's existence.

F. Visits are being made with funding sources outside the University when it is appropriate.

IV. Concept of the Center -

A. Objective -

Develop a Center for Alternative Crops and Products within the College of Agriculture that features a partnership with industry. The focus of this Center will be twofold; new crops and alternative uses of existing crops.

B. Purpose -

1. To act as an integrated market-driven forum for systematically investigating the economic and cultural feasibility of growing and/or processing alternative crops for the Upper Midwest.

   a.To serve as a multidisciplined evaluative clearinghouse for ideas and current activities.

   b.To identify limiting technologies and assess potential on the basis of scope and risk analysis.

   c.To establish research and development priorities and recommend new initiatives or reaffirm current programs.

2. To discover, collect, and disseminate information in an organized manner on a wide range of crops and processes.

3. To actively involve all relevant resources including Departments of the University of Minnesota, other research institutions of the region, industries involved in food, feed, and manufacturing, and clientele representatives.

4. To seek new resources and to channel current resources in the broad investigation and development of identified alternative crops and/or process potential.

5. To model market development and pilot field and manufacturing processes as techniques for demonstrating feasibility and determining risk.

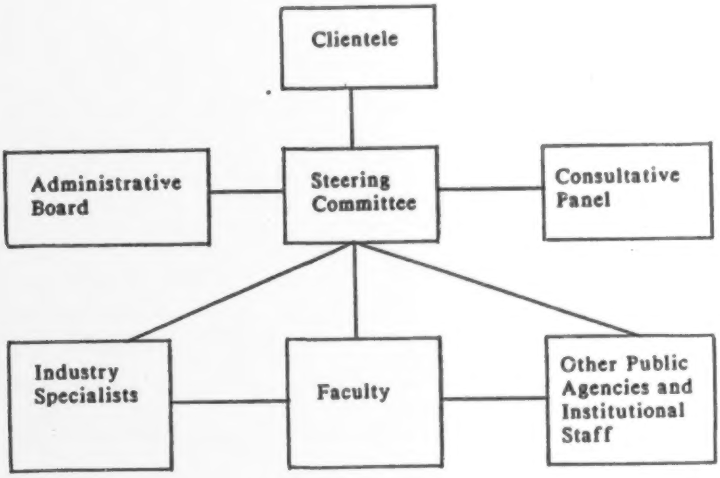
6. To provide a clearly identifiable center to assist in drawing scientists (visiting scientists, people on leave, etc.) and graduate students from other regions.

7. To encourage an effective, professional liaison with the legislature, Congress and concerned citizens groups relating to alternative crops.

C. Organization -

The Center will be administered by an Administrative Board composed of the Director of the Experiment Station as Chair, the Assistant Director of Extension for Agriculture as Vice Chair, and involved COA department heads. Participants will include interested faculty, invited R&D managers and representatives of the agricultural industry, and other public agencies. A Consultative Panel will be advisory in nature and made up of representatives of industry organizations.

ORGANIZATION STRUCTURE


Clientele
Administrative Board
Steering Committee
Consultative Panel
Industry Specialists
Faculty
Other Public Agencies and Institutional Staff

D. Ways and Means -

1. A Steering Committee will develop the concept of the Center and direct implementation.
2. Organization development will be initiated as need, demand, and scope are identified.
3. The Steering Committee will make grant applications to appropriate sources of funding.
4. Funds directed and reallocated internally will assure multidisciplined involvement of faculty on focused objectives.
5. Funding support may be developed on royalties contracts for information, consulting fees, and membership dues as the opportunities arise and are deemed appropriate by the Steering Committee and Administrative Board.

V. Sponsored Symposia -

A continuous series of intensive, indepth symposia will be conducted (two per year initially) that will focus on important crop product areas. These symposia will be advertised widely (nationally and internationally) and will contribute to a growing information data base. These symposia will be conducted with the cooperation of the Office of Special Programs.

VI. Sponsored Research and Development Projects -

A. Idea Generation, Receipt and Evaluation

1. Source of Ideas -

Ideas may be submitted to the Center for consideration by anyone prepared to develop a written preproposal and present it in an oral evaluation. The Center will have an "open door" policy for receiving ideas and will publicize the availability of the Center as a clearinghouse for ideas and their evaluation. Preproposals submitted will have sufficient documentation to permit preliminary evaluation by the steering committee and the Administrative Board and it will include at least the following:

a. Identification of the potential crop or crop use.

b. Current status.

c. Potential use and value.

d. Problems and limitations.

2. Idea Evaluation -

Ideas received will be reviewed by the Center steering committee. The preliminary evaluation will be based upon:

a. Market potential.

b. Crop characteristics and biology.

c. Uniqueness.

d. Funding potential.

e. Potential for general public interest.

A Center staff member will conduct a review of the subject to document the state of current knowledge. The report will address any concerns raised during review by the steering committee and the Administrative Board.

The results of this evaluation will be communicated to the originator with an explanation of the action recommended. If more information is required to evaluate the idea, some technical assistance will be provided to assist the originator, if requested, in resubmitting the preproposal. For ideas receiving favorable evaluation, the originator will be invited to present the idea and preproposal in an oral Evaluation Session. These sessions will be well-advertised open forums with special invitations made to individuals and organizations/agencies who might have special interest in the area. Sufficient time will be provided to present the idea and permit adequate challenge.

Preproposals which are successful in an oral Evaluation Session will be returned to the steering committee for further action.

B. Action on Successful Preproposals -

1. Detailed Technical Review -

The Steering Committee will select a special committee of individuals with the expertise to provide a detailed technical review of the preproposal. This special committee will be provided with available information pertinent to the proposal including the report of the state of current knowledge. This Technical Review Committee will be asked to make action recommendations to the Steering Committee and establish research and development priorities.

2. Research and Development -

In order to implement action recommendations, the Steering Committee will encourage individuals with special expertise to work on problems identified in the idea evaluation process. This R & D group will work with the Center to develop a detailed plan of activities including identifying funding sources, preparing proposals for funding, establishing priorities and schedules of activities, and implementing research and development plans. These individuals will be encouraged to meet regularly and review progress.

The Center will be actively involved in assisting with funding of activities and providing the leadership for research and development activities. A progress report will be prepared by the R & D group for inclusion in the Center's Annual Report.

4. Final Center Project Report -

At the completion of the work on a project, each project area will prepare a report of their activities, results, and recommendations. These individual reports and the report of the state of knowledge will be compiled by the Center into a Final Project Report and Recommendations. This report will be made available to the public.

C. Dissemination of Information and Recommendations -

The information gathered during evaluation of proposal ideas, and research and development activities will be presented by project participants in a publicized forum. Their presentations will be open to the public with special invitations to individuals or groups with interest in the area.

D. Idea Development Procedure Summary Flow Plan -

Idea (Proposal)
↓
Steering Committee
↓
Board of Directors
↓
Current Situation Report
↓
Oral Evaluation Session
↓
Steering Committee
↓
Board of Directors
↓
Technical Review, Action Recommendations, and R & D Proposal
↓
Research and Development
↓
Final Center Project Report and Recommendations
↓
Dissemination of Information and Recommendations

VII. Criteria for Measuring and Evaluating Success -

Initially, the interest shown in the services provided by the Center will provide adequate indication of the usefulness of the concept. For specific programs, such as the Symposia, the Steering Committee will be responsible for generating feedback from participants.

VIII. Present and Projected Resources -

A. The faculty and their collective expertise.

B. University and industry facilities that will be used in cooperative projects.

C. Funds from the current University request to the Minnesota legislature.

D. Funds from government agencies such as the Governor's Rural Development Council, the Department of Energy and Economic Development, the State Department of Agriculture, etc.

E. Funds from Foundations and Industry.

F. Gifts and grants from individual benefactors.

IX. Classification of Expenditures for 1986-87 and 1991-92 -

	1986-87* Jan-June 87	1991-92
Director (.5 FTE)	$16,000	$38,000
Research Associate(s)	32,000	140,000
Clerical (Administrative Asst.)	15,000	33,000
Equipment (office)	10,000	5,000
Office Operation	2,000	4,000
Travel	5,000	10,000
Center Brochure (Literature) and Printing	2,000	5,000
Preliminary Support for Projects	20,000	200,000
Total	$102,000	$435,000

*Assumes that funds currently being sought can be generated early in 1987.

X. Ranking of Priorities at Current Funding -

A. Conduct series of symposia.

B. Refine organizational structure and operational procedure.

C. Discuss the concept of the Center with concerned individuals and groups, and potential funding sources and participants (including the COA faculty).

D. Pursue reallocation of existing funding in the Experiment Station and Extension.

XI. Funds Possibly Available for Reallocation -

A. A proposal will be written to the Experiment Station for funds originating from the current University request to the legislature.

B. Extension will be approached regarding the availability of computer facilities for Center operation.

C. The .5 FTE of the Center Director.

D. Time of the Steering Committee members.

XII. Priorities with Increased Funding -

A. Full implementation of research and development activities.

B. The Center will become functional as a contact point of the University and a clearinghouse for relevant ideas.

XIII. Impact on Space, Computing Capacity, Other Programs and Libraries -

The Center will not draw upon existing resources within the University of Minnesota. It is expected that faculty involved in research and development activities will more fully utilize their existing facilities and funded research should contribute to the maintenance and replacement of those facilities. The Center will require a minimal amount of administrative space on the St. Paul campus. It is the intent of the Steering Committee that the Center not become a bureaucracy but rather function as an organization to facilitate cooperative activities in solving problems.